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Benzene Fugitive Emissions Background Information for Promulgated Standards

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Benzene Fugitive Emissions—

Background Information for Promulgated Standards

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16. ABSTRACT
A national emission standard for the control of fugitive emissions of benzene from the petroleum refining and organic chemical manufacturing industries is being promulgated under Section 112 of the Clean Air Act (42 U.S.C. 7412, as amended). This standard will limit fugitive emissions of benzene from existing and new equipment in benzene service. This document summarizes the responses to public comments received on the proposed standards and also summarizes the basis for changes made in the standards since proposal.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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ENVIRONMENTAL PROTECTION AGENCY

Background Information
Final Environmental Impact Statement
Benzene Fugitive Emissions

Prepared by:

Jack R Farmer 5/25/84

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1. The promulgated national emission standard will limit fugitive emissions of benzene from existing and new equipment in benzene service. The promulgated standard implements Section 112 of the Clean Air Act and is based on the Administrator's determination of June 8, 1977, (42 FR 29332) that benzene presents a significant risk to human health as a result of air emissions from one or more stationary source categories and is, therefore, a hazardous air pollutant.

2. Copies of this document have been sent to the following Federal Departments: Office of Management and Budget; Labor, Health and Human Services, Defense, Transportation, Agriculture, Commerce, Interior, and Energy; the National Science Foundation; the Council on Environmental Quality; members of the State and Territorial Air Pollution Program Administrators; the Association of Local Air Pollution Control Officials; EPA Regional Administrators; and other interested parties.

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1.0 SUMMARY

1.1 INTRODUCTION

On January 5, 1981, the Environmental Protection Agency (EPA) proposed the national emission standard for benzene fugitive emissions (46 FR 1165) under authority of Section 112 of the Clean Air Act. Public comments were requested on the proposal in the FEDERAL REGISTER. EPA received 30 comment letters on the proposed standard. Industry representatives submitted most of the comments. Also commenting were representatives of State and local air pollution agencies and a representative of an environmental group. The comments that were submitted, along with responses to these comments, are summarized in Chapter 2 of this document. The summary of comments and responses serves as the basis for the revisions made to the standard between proposal and promulgation.

1.2 SUMMARY OF CHANGES SINCE PROPOSAL

The proposed regulation was extensively revised for promulgation. Significant changes were made in the following areas:

- Standards for pumps and compressors
- Requirements for difficult-to-monitor and unsafe-to-monitor valves
- Alternative standards for valves
- Delay of repair provisions
- Requirements for control devices
- Calibration gas requirements for Reference Method 21
- Alternative requirements for vendors and manufacturers
- Reporting requirements
- Benzene usage cutoff

1.2.1 Standards for Pumps and Compressors

Since proposal, EPA has analyzed the annualized cost of controlling benzene emissions and the resultant emission reduction for each alternative control technique for each fugitive emission source. Based on comparison of incremental costs and emission reductions, EPA reconsidered the basis for selection of the best available technology (BAT). After selection of BAT, EPA considered the next more restrictive level of control before selecting the final standard. (See Section 2.3 for a full discussion on the selection of the final standard.) As a consequence of this reconsideration, the standard has changed since proposal for two fugitive emission sources: pumps and compressors.

The proposed standard for pumps included the use of dual mechanical seals. Since proposal, the standard has changed to a leak detection and repair program for pumps. The leak detection and repair program requires monthly leak detection of benzene-handling pumps in light liquid service. Leak detection is to be performed with a portable organic compound analyzer according to Reference Method 21. If a reading of 10,000 ppm or greater of organic compound is obtained, a leak is detected. Initial repair of the leak must be attempted within 5 days, and the repair must be completed within 15 days. Delay of repair will be allowed for pumps that can not be repaired without a process unit shutdown. Delay of repair is also allowed when the plant owner or operator determines that repair of the pump requires using a dual mechanical seal system. Delay of repair is not expected to be needed for most situations, however, because pumps are commonly spared. The bases for selection of the leak detection and repair requirements for pumps are discussed in Section 2.4.2 of this document as responses to comments pertaining to these requirements.

The equipment standard for pumps also has been incorporated into the final standard. If an owner or operator prefers, he or she may comply with the equipment standard. The details or provisions of the equipment standard have not been changed substantially since proposal.

For new and existing compressors, the control costs incurred for each megagram of emission reductions were determined for equipment controls. A leak detection and repair program was not considered for the final standard because installation of equipment is the only viable control technique for compressors. A leak detection and repair program for compressors is not effective because the repair of a leak on a compressor requires the installation of equipment. Because installation of the equipment requires a process unit shutdown and because compressors generally are not spared, repair would be delayed until the next turnaround. Such an approach would result in little, if any, emission reduction. Because of this and the considerations presented in Section 2.3, use of control equipment was selected as the standard for compressors. EPA expects very few compressors in benzene service.

1.2.2 Requirements for Difficult-to-Monitor and Unsafe-to-Monitor Valves

Some valves are difficult to monitor because access to the valve is restricted. Difficult-to-monitor valves can be eliminated in new process units but can not be eliminated in existing process units. For new units, all valves will be subject to the proposed leak detection and repair program. However, for existing process units, the standard has been changed since proposal to allow an annual leak detection and repair program for valves that are difficult to monitor. Valves that are difficult to monitor are defined as valves that would require elevating the monitoring personnel more than 2 meters above any permanent available support surface. This means that stepladders would be used to elevate monitoring personnel under safe conditions. However, valves that cannot be safely monitored by the use of step ladders could be classified as difficult to monitor.

In addition, some valves are unsafe to monitor. Valves that are unsafe to monitor cannot be eliminated in new or existing units. The final standard has been changed to allow an owner or operator to submit a plan that defines a leak detection and repair program conforming with the routine monitoring requirements of the standard as much as possible given that monitoring should not occur under unsafe conditions. Valves that are unsafe to monitor are defined as those valves that could, as demonstrated by the owner or operator, expose monitoring personnel to imminent hazards from temperature, pressure, or explosive process conditions. EPA expects few valves in benzene service that are unsafe to monitor.

1.2.3 Alternative Standards for Valves

At proposal, two alternative standards were presented for valves. Both of these alternatives called for 1 year of monthly monitoring to obtain data on which to base the alternative standard. One alternative standard was based on an allowable percentage of valves leaking. Because an industry-wide allowable leak percentage is not possible due to variability of leak frequency among process units, an allowable percentage of valves leaking would have been determined for each process unit based on data collected in that unit. A minimum of one performance test was required annually. The other alternative standard for valves allowed the development of work practices that would achieve the same result as the proposed leak detection and repair program. This alternative allowed an owner or operator to change the monitoring interval if the resultant emission reductions were the same as those associated with the standard.

Based on comments received on the proposed alternative standards and on analysis of the results from recent screening and maintenance studies, the alternative standards for valves were reexamined. As a result, the alternative standards were changed. In making these changes, EPA considered information gathered on benzene-producing and consuming process units.

The first alternative standard specifies a 2 percent limitation as the maximum percent of valves leaking within a process unit, determined by a minimum of one performance test annually. EPA agrees with the commenters that this will provide an incentive to maintain a good performance level and promote low-leak unit design. This standard provides the flexibility of a performance level that could be met by implementing any type of leak detection and repair program and engineering controls chosen at the discretion of the owner or operator. Even though an industry-wide allowable leak percentage was not possible for valves, this alternative standard would allow a process unit to comply with an allowable percentage of valves leaking without having to determine a specific performance level by a year-long monthly monitoring program. If the results of a performance test show a percentage of valves leaking higher than 2 percent, however, the process unit would not be in compliance with the standard. Finally, if an owner or operator determines that he or she no longer wishes to comply with this alternative standard, he or she can submit a notification in writing to the Administrator stating that he or she will comply with the routine (monthly/quarterly) leak detection and repair program specified in §61.242-7(a)-(e).

The second alternative standard specifies two statistically-based skip-period leak detection and repair programs. Under skip-period leak detection, an owner or operator can skip from routine monitoring (monthly/quarterly) to less frequent monitoring after completing a number of consecutive monitoring intervals with performance levels less than 2 percent. This approach provides that the performance level is achieved for each skipped period for better than a 90 percent certainty. Two sets of consecutive periods and fraction of periods skipped were determined for benzene process units. First, after two consecutive quarterly periods with less than 2 percent of valves leaking, an owner or operator may skip to semiannual monitoring. Second, after five consecutive quarterly periods with less than 2 percent of valves leaking, an owner or operator may skip to annual monitoring. This alternative standard also requires that, if a process unit exceeds the 2 percent of valves leaking, the owner or operator must revert to the monthly/quarterly leak detection and repair program that is specified in §61.242-7(a)-(e). Compliance with this alternative standard would be determined by inspection and review of records.

1.2.4 Delay of Repair Provisions

EPA recognized at proposal that, in a few cases, repair of leaking sources may be delayed for specific reasons while the owner or operator is making a good faith effort to comply with repair time limits. Commenters presented additional reasons for delay of repair. EPA reviewed these reasons and considered some of them reasonable. Therefore, the delay of repair provisions have been expanded in the final standard.

In the proposed standard, delay of repair was allowed where repair is technically or physically infeasible without a process unit shutdown. An example of such a situation would be a leaking valve that could not be isolated from the process stream but which requires complete replacement or replacement of multiple internal parts. In this case, the process unit would have to be shut down to effect repairs on the valve, since the valve could not be physically isolated from the process stream. The final standard includes the same provision as the proposed standard in that it does not require that the process unit be shut down for repairs. In addition to the provision already in the proposed standard, several new provisions have been added to the final standard.

One new provision allows for delay of repair beyond a process unit shutdown for valves when unforeseeable circumstances deplete valves used in repair. Another new provision has been added to avoid causing extended delays in returning a process unit to production if the unit shuts down briefly due to unforeseen circumstances. Delay of repair beyond an unforeseen process unit shutdown will be allowed if the shutdown is less than 24 hours in duration. Repair of leaking fugitive emission sources for which repair has been delayed would be required at the next process unit shutdown.

As part of the repair requirements, EPA is clarifying its intent for spare fugitive emission sources that do not remain in benzene service. Delay of repair of benzene fugitive emission sources for which leaks have been detected will be allowed for sources that no longer contain benzene in concentrations greater than 10 percent. These fugitive emission sources must be purged to a system that complies with the requirements for closed-vent systems and control devices. Delay of repair will not be allowed, however, for spare equipment that contains process fluids and is prepared to be placed on-line; such equipment is considered to be in benzene service.

In addition, a provision has been added to allow delay of repair for certain leaking pumps. Sometimes, leaking pumps cannot be repaired under the leak detection and repair program unless the owner or operator installs dual seals with barrier fluid systems. For these leaking pumps, a delay of repair for a period of 6 months will be allowed to install the required equipment. Another new provision is added to allow delay of repair for valves if the owner or operator shows that leakage of purged material after immediate repair is greater than the fugitive emissions that are likely to result from delay of repair.

1.2.5 Requirements for Control Devices

1.2.5.1 Combustion Devices and Vapor Recovery Systems. The temperature and residence time specified for combustion devices in the proposed standard (0.5 seconds at minimum 760 °C) were based on data analyzed in an EPA memo ("Thermal Incinerators and Flares") dated August 22, 1980 (Docket No. A-79-27-II-B-35). The data base contained in this memo included Union Carbide laboratory studies, EPA and industry field tests, and 147 tests on existing incinerators in Los Angeles County. These data indicate that greater than 98 percent efficiency is attainable by incinerators operating at 816 °C (1500 °F) and 0.75 seconds residence time. The memo concludes that 98 percent efficiency, or less than 20 ppmv (total organics minus methane and ethane) in the exhaust stream, is achievable in many situations at less than 871 °C (1600 °F) and 0.75 seconds residence time. The temperature and residence time required in the proposed standard were set at a level representative of 95 percent efficiency, the degree of emission reduction required of control devices in the proposed standard.

While thermal incinerators are proven control devices for destruction of benzene emissions, they are not the only enclosed combustion devices that could be used. In fact, boilers and process heaters already existing on-site are expected to be used for eliminating the small benzene streams covered by the standard. In order to ensure that these combustion systems achieve the requisite degree of control while reducing the burden associated with demonstrating compliance with this standard, the temperature-residence time requirements for enclosed combustion devices (i.e., 0.5 seconds at a minimum of 760 °C) have been retained in the final standard. However, any temperature and residence time combination is allowed by the standard provided the owner or operator demonstrates that the control device achieves a 95 percent destruction efficiency.

Other combustion systems, such as catalytic incinerators, are also applicable to the control of small benzene streams. Systems which employ catalysts, however, typically operate at lower temperatures and would not be able to meet these operating requirements. Therefore, the temperature-residence time requirements will not apply to combustion systems which employ catalysts. This change will permit the use of catalytic combustion units for control of benzene fugitive emissions without an equivalency determination. However, the owner or operator must demonstrate that the control device achieves a 95 percent destruction efficiency.

The requirements for vapor recovery systems have not changed since proposal. They require a 95 percent reduction of benzene emissions to the atmosphere.

1.2.5.2 Flares. At proposal, flares were not specifically listed as an acceptable control option for the reduction of fugitive emissions of benzene. The results of available flare efficiency studies were not considered relevant. The gas streams tested were not considered representative of the streams to be controlled. In some cases the flare design was not representative of flares in the industry. In others the analytical method was questionable. No method for measuring flare efficiency (evaluating flare performance) was available. Theoretical calculations indicated that flare efficiency could be as low as 60 percent for destruction of benzene in low-flow intermittent streams sent to a large flare. This efficiency was cited in several background documents (Ethylbenzene/Styrene, Benzene Fugitive, SOCMI Fugitive VOC) and served as a primary consideration in not specifically allowing the use of flares.

Since proposal, the use of flares was reconsidered for the benzene fugitive emissions standard. Further actual flare measurement results have become available, most notably from the CMA-EPA study (IV-A-28)*, since the 60 percent theoretical estimate was made. In the CMA-EPA study, steam-assisted flares, air-assisted flares, and flares operated without assist were investigated over a wide range of exit velocity, gas composition, and flare gas heat content conditions. After review of available flare efficiency data (see Section 2.4.1.1), EPA has concluded that smokeless flares operated with a flame present and exit velocities less than 18 m/sec (60 ft/sec) with flare gas heat contents greater than 11.2 MJ/scm (300 Btu/scf) for steam-assisted flares or exit velocities less than 18 m/sec (60 ft/sec) and flare gas heat contents greater than 7.45 MJ/scm (200 Btu/scf) for flares operated without assist are acceptable alternatives to enclosed combustion devices (incinerators, boilers, process heaters) and vapor recovery systems, such as carbon adsorbers and condensation units. Air-assisted flares operated smokelessly with a flame present are also permitted if the heat content of the flared gas is above 11.2 MJ/scm (300 Btu/scf) and the exit velocity meets maximum velocity criterion, which is dependent upon the heat content of the gas. They may be applied to control of emissions from pump seals (or degassing reservoirs), compressor seals (or degassing reservoirs), pressure relief devices, and other fugitive emission sources. The requirement for the presence of a flame can be ensured by monitoring the flare's pilot light with an appropriate heat sensor, such as a thermocouple. To ensure somkeless operation, visible emissions from a flare would be limited to less than 5 minutes in any 2-hour period. EPA plans to update these requirements as new information is obtained.

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*References to Docket Entry Numbers for Docket No. A-79-27 are presented in this manner throughout this document.

1.2.6 Calibration Gas Requirements for Reference Method 21

EPA considered two calibration gases for the use of Reference Method 21 (See 40 CFR Part 60 Appendix A) in screening fugitive emission sources of benzene--hexane and methane. Prior to proposal, hexane was specified in the standard as the calibrant for the draft of Reference Method 21. At proposal, the calibration gas was changed to methane because methane is more readily available in the required concentration range. The change was made in response to comments on the draft regulatory package. However, during the public comment period for the proposed standard, other commenters objected to the change from hexane, saying the change eliminated the use of photoionization monitors and would mean that more leaks were detected. EPA has considered the differences in the results that would be obtained with the two calibrants and finds the differences insignificant. The differences are in the same range as the variability seen in repeated emission measurements from the same source. Data collected using hexane and methane can be used interchangeably within ±30 percent at the action level. Therefore, because the differences are insignificant and because the allowance of hexane as a calibration gas will provide for the use of photoionization monitors, EPA has changed the leak detection requirements to allow hexane as an alternate calibration material.

1.2.7 Alternative Requirements for Vendors and Manufacturers

The final standard has been changed to allow a vendor or manufacturer to apply for permission to use alternative control systems or equipment. This change was made to increase efficiency in the permission process and to provide plant owners and operators the incentive to purchase improved control systems and equipment as they are developed.

Even though the provision allowing vendors and manufacturers to apply for permission has been added, it should be remembered that the ultimate responsibility for properly using an alternative method is with the owner or operator, not the vendor or manufacturer.

1.2.8 Reporting Requirements

The promulgated standard includes reporting provisions requiring periodic reports of leak detection and repair efforts within a process unit. The amount of reporting and the associated burden with the reporting have been reduced from those in the proposed standard. In particular, quarterly reporting as required in the proposed standard has been reduced to semiannual reporting. The specific reporting provisions of the final standard have been changed in response to industry's comments on the proposed reporting provisions. EPA believes that these provisions will provide an efficient and effective means of enforcing the standard.

1.2.9 Benzene Usage Cutoff

An analysis by EPA indicated that the cost effectiveness of the standard for equipment at plant sites processing less than 1,000 Mg/yr is unreasonably high. Because this cost is unreasonably high in comparison to the minimal emissions reduction achievable, EPA provided an exemption for plants designed for low benzene usage. Plants with usage rates of 1,000 Mg of benzene/yr or less are exempt from the standard. It is expected that this cutoff will exempt most research and development facilities and other small-scale operations.

1.3 SUMMARY OF IMPACTS OF PROMULGATED ACTION

1.3.1 Alternatives to Promulgated Action

Regulatory alternatives are discussed in Chapter 6 of the background information document (BID) for the proposed standard, EPA-450/3-80-032a.

These regulatory alternatives reflect the different levels of emission control from which one was selected as the proposed best available technology, considering costs, nonair quality health, and environmental and economic impacts for benzene fugitive emission sources. Since proposal, these alternatives have changed slightly. At proposal, Regulatory Alternatives III and IV were selected as the basis for the standard for existing and new sources, respectively. Since proposal, EPA selected the final standard from alternative control techniques for each fugitive emission source rather than selecting the standard from various combinations of control techniques and sources. The only difference between the proposed and final standard with regard to selection of control techniques is the requirements for existing compressors and new pumps. In the proposed standard EPA required monthly monitoring of existing compressors. In the final standard, EPA is requiring control equipment for existing compressors as discussed in Section 1.2.2. The final standard for new pumps now requires monthly monitoring instead of the installation of dual seal systems. Therefore, the requirements for new and existing pumps are the same in the final standard (monthly monitoring). Requirements for the other sources remain unchanged.

1.3.2 Environmental Impacts of Promulgated Action

Environmental impacts of the standard are described in Chapter 7 of the BID for the proposed standard. Since proposal, EPA has reanalyzed the environmental impacts of the standard and has found the overall effect on these impacts has not substantially changed. EPA has revised the baseline emission estimate (discussed in Section 2.8.2) and the estimate of benzene fugitive emissions to atmosphere that will be reduced by the standard. The revisions were made as a consequence of revising methods of analysis (i.e., baseline emission estimate) and incorporating the leak detection and repair model for valves and pumps, as described in Appendix B of this document.

The standard will reduce benzene fugitive emissions to atmosphere from 7,920 Mg/yr to 2,470 Mg/yr for existing units. This reduction represents a 69 percent decrease in emissions for existing units from the current industry baseline level of emissions. Assuming that standards of performance for fugitive emission sources of VOC (those covering synthetic organic chemical manufacturing and petroleum refinieries) would not cover benzene fugitive emission sources, the standard would reduce benzene fugitive emissions from 2400 Mg/yr to 680 Mg/yr for new units constructed between 1980 and 1985. Because, however, these standards of performance would reduce fugitive emissions of benzene, the amount reduced over what would be reduced without the benzene fugitive emissions standard is less than indicated above. Because the emission reductions are about the same as the proposed estimates and because the water quality and solid waste impacts are generally proportional to the emission reductions, the water quality and solid waste impacts are similar to those presented in the BID for the proposed standard.

With the changes noted above, the analysis of the environmental impact in the BID for the proposed standard now becomes the final Environmental Impact Statement for the promulgated standard.

1.3.3 Energy and Economic Impacts of Promulgated Action

Section 7.5 of the BID for the proposed standard describes the energy impacts of the standard. The changes made in the standard have decreased slightly the energy impacts of the standard because the energy value and crude oil equivalent of benzene emission reductions are lower.

Chapters 8 and 9 of the BID for the proposed standard describe the cost and economic impacts of the proposed standard. Since proposal, the cost analysis of the standard has been revised to incorporate new emission reduction estimates from the leak detection and repair model for valves and pumps. As discussed in Chapter 2 (Sections 2.3 and 2.6), the economic impact of the final standard is reasonable.

1.3.4 Health Impact of Promulgated Action

Since the standard was proposed, EPA has revised the baseline benzene fugitive emissions estimate, the estimated emission reductions resulting from the standard, and the risk assessment for leukemia risk from benzene fugitive emissions (see Section 2.8.2 of this document for a discussion of changes to the baseline and emission reduction estimates, and see Appendix C for complete descriptions of the revisions to the risk assessment). Benzene fugitive emissions are estimated to be 7,920 Mg/yr in 1980 in the absence of a benzene fugitive emissions standard. The final standard is expected to reduce these emissions by 69 percent. In its revised estimate, EPA has calculated that, in the absence of a benzene fugitive emissions standard, the leukemia incidence would be about 0.45 cases per year within this population due to exposure to benzene fugitive emissions from existing sources and about 0.12 cases per year from exposure to new sources of benzene fugitive emissions (assuming relevant standards of performance might not affect benzene fugitive emissions). Further, EPA has estimated that for the maximally exposed persons, the chance of contracting leukemia as a result of exposure to fugitive benzene emissions would be about 1.5×10^{-3} per lifetime for existing sources. Due to the assumptions which were made in calculating these maximum lifetime risk and leukemia incidence numbers, there is uncertainty associated with the numbers presented here. The use of the risk numbers is explained in the section entitled "Need for the Standard." However, with the standard in place, the standard will reduce these health impacts by 69 percent.

1.3.5 Other Considerations

1.3.5.1 Irreversible and Irretrievable Commitment. Section 7.6.1 of the BID for the proposed standard concludes that the standard will not result in any irreversible or irretrievable commitment of resources. It was also concluded that the standard should help to save resources due to the energy savings associated with the reduction in emissions. These conclusions remain unchanged since proposal.

1.3.5.2 Environmental and Energy Impacts of Delayed Standards. Tables 1-1 and 7-13 in the BID for the proposed standard summarize the environmental and energy impacts associated with delaying promulgation of the standard. The revised air and energy impacts are shown in Table 1-1 of this document. The emission reductions and associated energy savings shown would be irretrievably lost at the rates shown for each of the 5 years.

Table 1-1. IRRETRIEVABLE LOSSES THAT WOULD OCCUR IF STANDARD IMPLEMENTATION WERE DELAYED

Year	Benzene Emission Reductions Attributable to the Standard, Gg[a]	Energy Value of Benzene Emission Reductions, TJ[b]	Crude Oil Equivalent of Benzene Emissions Reductions, 10^3 barrels[c]
1981	5.7	49.1	8.0
1982	6.1	52.5	8.6
1983	6.4	55.1	9.0
1984	6.8	58.5	9.6
1985	7.2	62.0	10.1
5-year Total	32.2	277.2	45.3

[a] Estimated benzene emission emission reduction attributable to the standard. This value is calculated as the difference between industry-wide baseline benzene emissions (petroleum refining process units in NAAQS nonattainment areas for ozone are regulated by refinery VOC CTG control; all other benzene handling process units are uncontrolled) and industry-wide benzene emissions under the benzene fugitives NESHAP

[b] Energy value of benzene is 8.6054 TJ/Gg (17,986 Btu/lb). Refer to the BID for the proposed standard, Table 7-13. Energy values obtained by multiplying benzene emission reductions by conversion factor.

[c] Crude oil equivalent for benzene is 6.12×10^{-3} TJ/bbl of crude oil. Refer to the BID for the proposed standard, Table 7-13. Crude oil equivalent values obtained by dividing the energy value of benzene emission reductions by conversion factor.

2.0 SUMMARY OF PUBLIC COMMENTS

Commenters' affiliation, comment EPA docket number, and date of comment for every comment received are listed in Table 2-1. Thirty letters and documents on the proposed standard and its background information document (BID) were received. Significant comments have been divided into the following eight sections:

2.1. Legal Considerations and Need for the Standard
2.2 Health Effects and Risk Assessment of Benzene Exposure
2.3. Selection of the Final Standard
2.4. Control Technology
2.5. Recordkeeping and Reporting
2.6. Costs
2.7. Test Methods and Procedures
2.8. General Issues

Comments, issues, and responses are discussed in the following sections of this chapter. Changes to the regulation are summarized in Section 1.2 of Chapter 1.

In several instances, commenters have requested that EPA incorporate all of their comments on other EPA rulemakings. For these comments, where EPA's response is identical to the response given in the other rulemaking, EPA is simply referring to the identical response given in the other rulemaking. In Section 2.8 (General Issues), EPA has included a table that lists the significant comments of this sort and refers to the location of the responses.

2.1 LEGAL CONSIDERATIONS AND NEED FOR THE STANDARD

2.1.1 Benzene Listing

Several commenters stated that benzene should not have been listed as a hazardous air pollutant under Section 112 of the Clean Air Act, and that, therefore, the proposed benzene fugitive NESHAP should

Table 2-1. LIST OF COMMENTERS ON THE PROPOSED NATIONAL EMISSION STANDARD FOR BENZENE FUGITIVE EMISSIONS

Docket Reference Number and Date[a]	Comment Affiliation
1. IV-F-1; July 14, 1981	Hearing transcript
2. IV-F-2; July 14, 1981[b]	Chemical Manufacturers Association
3. IV-D-1; January 9, 1981	Kirkland & Ellis for API
4. IV-D-2; February 4, 1981	Louisiana Dept. of Natural Resources
5. IV-D-3; February 19, 1981[c]	Kirkland & Ellis for API
6. IV-D-4; March 11, 1980[d]	Phillips Petroleum Company
7. IV-D-5; September 11, 1980[d]	Union Carbide Corporation
8. IV-D-6; December 22, 1980[d]	Sun Petroleum Products Company
9. IV-D-7; March 16, 1981[c]	Kirkland & Ellis for API
10. IV-D-8; April 1, 1981	Air Products and Chemicals, Inc.
11. IV-D-9; November 7, 1980[d]	Dow Chemical U.S.A.
12. IV-D-10; April 20, 1981	Erie County, New York, Dept. of Environment and Planning
13. IV-D-11; June 15, 1981	Cities Service Company
14. IV-D-12; June 5, 1981[c]	Kirkland & Ellis for API
15. IV-D-13; July 13, 1981	American Petroleum Institute
16. IV-D-14; August 7, 1981	Chemical Manufacturers Association
17. IV-D-15; August 7, 1981[e]	Monsanto
18. IV-D-16; September 4, 1981	Merck Chemical Manufacturing Div.
19. IV-D-17; September 10, 1981	Chevron USA
20. IV-D-18; September 9, 1981	Shell Oil Company
21. IV-D-19; September 11, 1981	Pennzoil Company
22. IV-D-20; September 8, 1981	Gulf Oil Company, U.S.
23. IV-D-21; September 14, 1981	Chemical Manufacturers Association
24. IV-D-22; September 14, 1981	Universal Oil Products
25. IV-D-23; September 11, 1981[e]	Kerr-McGee Corporation
26. IV-D-24; September 11, 1981	Monsanto Company
27. IV-D-25; September 10, 1981	Dow Chemical Company
28. IV-D-26; September 11, 1981	Phillips Petroleum Company
29. IV-D-27; September 14, 1981	American Petroleum Institute

Table 2-1. LIST OF COMMENTERS ON THE PROPOSED NATIONAL EMISSION STANDARD FOR BENZENE FUGITIVE EMISSIONS (Concluded)

Docket Reference Number and Date[a]	Commenter Affililiation
30. IV-D-28; September 11, 1981	Texaco, Inc.
31. IV-D-29; September 14, 1981	American Cyanamid Company
32. IV-D-30; September 8, 1981	Standard Oil Company
33. IV-D-31; September 14, 1981	Natural Resources Defense Council, Inc.
34. IV-K-1; September 11, 1981	Standard Oil Company (Indiana)

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[a] The docket number for benzene fugitives standard development is A-79-27. The docket is located at EPA Headquarters in Washington D.C.

[b] This reference is a transcript submitted by the commenter at the public hearing and is essentially identical to the oral testimony.

[c] No response is given because the letter requested an extension to the public comment period; therefore, the comment letter is not summarized in this document.

[d] These letters comment on test reports that were finalized prior to proposal and were inadvertently left out of the pre-proposal docket.

[e] This letter was inadverrtently placed in the benzene fugitives dockets; therefore, no comment summary or response is given.

be withdrawn. Various reasons were commonly cited to support this contention. These comments are summarized below.

Comment: Some commenters felt that benzene does not constitute the kind of risk deemed hazardous under Section 112 of the Clean Air Act (IV-D-28; IV-D-24; IV-F-1; IV-D-27; IV-K-1).

Response: Response to this comment can be found in "Response to Public Comments on EPA's Listing of Benzene Under Section 112" (EPA-450/5-82-003), which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

Comment: Several commenters stated that there exists little or no evidence to substantiate risk from emissions of benzene. One commenter stated that there is no evidence (IV-D-28), another stated that there is insufficient evidence (IV-D-17), and a third stated that the listing was based on an inadequate record (IV-D-19).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

Comment: Three commenters felt that the listing and rulemaking proceedings for benzene are premature since they are based on a draft EPA policy regarding airborne carcinogens (IV-D-8; IV-D-25; IV-D-26). One of the commenters felt that to proceed before the airborne carcinogen policy is finalized is a violation of Section 307 of the Clean Air Act and of Section 533 of the Administration Procedure Act (IV-D-8). One commenter felt that EPA exceeded its legal authority and offended good scientific practice in utilizing the airborne carcinogen policy to list benzene (IV-D-25).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

2.1.2 Need for the Standard

Several commenters contended that the proposed benzene fugitive emissions standard is not needed and, therefore, should be withdrawn. These comments address the following: (1) significance and relative proportion of risk associated with benzene fugitive emissions;

(2) duplication of federal and State regulations and guidelines; (3) information indicating that risks are smaller than estimated in the preamble to the proposed standards; (4) acceptable residual risk; and (5) lack of data to demonstrate risk.

Comment: Three commenters stated that EPA has not demonstrated that benzene fugitive emissions pose a significant risk that merits the adoption of a benzene fugitive emissions standard (IV-D-27, IV-F-1; IV-K-1). One of these commenters stated that Section 112 requires that a NESHAP be established at the level which in the Administrator's judgment provides "an ample margin of safety to protect the public health from such hazardous air pollutant." According to the commenter, last year the Supreme Court held that, absent a "clear mandate" from Congress to eliminate all risk, the statutory term "safe" (regarding exposure levels), rather than meaning "absolutely risk-free," means a level that protects against a "significant risk of harm." The commenter noted that risk levels that EPA has calculated are not "significant" as that term has been used by the Court (IV-K-1).

Two commenters felt that the risk from exposure to fugitive benzene is insignificant compared to other commonly accepted societal risks (IV-D-24; IV-D-27). One commenter noted that the risk from fugitive benzene emissions is insignificant in comparison to background leukemia risk (IV-D-28, IV-D-27). The commenter further compared the risk from fugitive benzene emissions to other government determinations of risk acceptability and noted that, under these determinations, the risk from exposure to benzene from fugitive emission sources would have been considered not worthy of regulation (IV-D-27).

Response: On June 8, 1977, EPA listed benzene as a hazardous air pollutant under Section 112 of the Clean Air Act. After careful consideration, EPA has not decided to delist benzene as a hazardous air pollutant, as discussed in EPA-450/5-82-003.

The commenters are judging the significance of benzene fugitive emissions based on quantitative risk estimates. In general, quantitative risk estimates at ambient concentrations involve an analysis of the effects of a substance in high-dose epidemiological or animal studies, and extrapolation of these high-dose results to relevant human exposure routes at low doses. In the case of benzene, the effects observed were the result of high-dose epidemiological studies. The mathematical models used for such extrapolations are based on observed dose-response relationships for carcinogens and assumptions about such relationships as the dose approaches very low levels or zero. Quantitative risks to public health from emissions of an airborne carcinogen may be estimated by combining the dose-response relationship obtained from this carcinogenicity strength determination with an analysis of the extent of population exposure to a substance through ambient air.

Most exposure analyses are based on air quality models, available estimates of emissions from sources of a substance, and approximations of population distributions near these sources. EPA considers this the best practicable approach. Even though ambient monitoring data might be used to estimate quantitative risks to public health, these data are available only for a few locations near these sources. Thus, use of ambient monitoring data is not practicable. However, EPA has data to confirm that the public is exposed to benzene. For example, concentrations up to 51 micrograms per cubic meter (on a 24-hour average) were found around a petrochemical plant in Philadelphia, Pennsylvania.

The air quality models used in exposure analyses generally estimate exposures of up to 20 kilometers. During exposure analyses, population and growth statistics are examined in conjunction with ambient concentrations. Using these factors and existing carcinogenicity strength determinations, estimates are then made of the degree of risk to individuals and the range of increased cancer incidence expected from ambient air exposures associated with a substance at various possible emission levels.

The assumptions and procedures discussed above for extrapolation and for exposure estimates for benzene emissions are subject to uncertainty. The ranges in estimates at proposal (presented below) of maximum lifetime risk and annual leukemia incidence from exposure to fugitive emission sources of benzene represent the uncertainty of estimates made concerning the benzene concentrations to which workers were exposed in the occupational studies of Infante, Aksoy, and Ott that served as the basis for developing the benzene unit risk factor (discussed in "Response to Public Comments on EPA's Listing of Benzene Under Section 112 and Relevant Procedures for the Regulation of Hazardous Air Pollutants," EPA-450/5-82-003 and in Appendix E of Benzene Fugitive Emissions--Background Information for Proposed Standard, EPA-450/3-80-032a). The ranges represent 95 percent confidence limits on two sources of uncertainty in the benzene risk estimates. One source derives from the variations in dose/response among the three occupational studies upon which the benzene unit risk factor is based. A second source involves the uncertainties in the estimates of ambient exposure. In the former case, the confidence limits are based on the assumption that the slopes of the dose/response relationships are unbiased estimates of the time slope and that the estimates are log normally distributed. In the latter case, the limits are based on the assumption that actual exposure levels may vary by a factor of two from the estimates obtained by dispersion modeling.

There are several other uncertainties associated with the estimated leukemia incidence that are not quantified in these ranges. Leukemia incidence was calculated based on a no-threshold linear extrapolation of leukemia risk associated with a presumably healthy white male cohort of workers to the general population, which includes men, women, children, nonwhites, the aged, and the unhealthy. These widely diverse segments of the population may or may not have differing susceptability to leukemia than do workers in the studies. Assumptions must be made in order to estimate exposed populations in census tracts. In addition, the exposed population is assumed to be immobile, remaining at the same location 24 hours per day, 365 days per year, for a lifetime (70 years). This assumption is counterbalanced to some extent (at least in the calculation of incidence) by the assumption that no one moves into the exposure area either as a permanent resident or as a transient. Assumptions that must be made to estimate ambient concentrations by dispersion modeling and exposed populations by census tract also introduce further uncertainties into the risk estimates in addition to the factor of two contained in the stated ranges. Modeled ambient benzene concentrations depend upon (1) plant configuration, which is difficult to determine for more than a few plants; (2) emission point characteristics, which can be different from plant to plant and are difficult to obtain for more than a few plants; (3) emission rates which may vary over time and from plant to plant; (4) meteorology, which is seldom available for a specific plant. The particular dispersion modeling used can also influence the numbers. The best model to use (ISC) is usually too resource intensive for modeling a large number of sources. Less complex models introduce further uncertainty through a greater number of generalizing assumptions. For example, an analysis shows that using the more complex ISC model rather than the less complex model used to estimate ambient benzene concentrations for fugitive emission sources (equipment leaks) would increase the estimated leukemia incidences for these sources by about 100 to 200 percent (Docket Item IV-B-18). Dispersion models also assume that the terrain in the vicinity of the source is flat. For sources located in complex terrain, the maximum annual concentration could be underestimated by several fold due to this assumption. Furthermore, leukemia is the only health effect of benzene considered. Other health effects, such as aplastic anemia and chromosomal aberrations are not quantified. Additionally, the benefits to the general population of controlling other hydrocarbon emissions from these fugitive emission sources are not quantified. Finally, these estimates do not include the cumulative or synergistic effects of concurrent exposure to benzene and other substances. Although the current health risk numbers are no longer presented as a range, they still contain the same uncertainties just described.

The decision to employ estimates of carcinogenic risks despite their lack of precision rests on the belief that, although they are subject to uncertainties, current analytical models and techniques can, with due consideration of the uncertainties, provide useful estimates of relative carcinogenic strength and of the probable general ranges of excess cancer incidence and individual risks. This view has been supported by the National Academy of Sciences,[a] the National Cancer Advisory Board,[b] and others.[c] In the case of benzene, EPA believes that in combination with the nature of the health evidence, the volume of emissions, and the size and distribution of the exposed population, the risk estimates are useful in the characterization and relative comparison of the extent of the benzene health hazard.

At the time the benzene fugitive emissions standard was proposed, EPA estimated benzene fugitive emissions to be 8,250 Mg/year in 1980 with no further regulation. The proposed standard was expected to reduce these emissions by approximately 75 percent. At proposal, EPA estimated that 65 million people live within 20 kilometers of existing units that produce or use benzene in the petroleum refining and chemical manufacturing industries. EPA calculated that, in the absence of a benzene fugitives standard, the annual leukemia incidence would be in the range of 0.15 to 1.14 cases per year within this population due to exposure to benzene fugitive emissions. Further, EPA estimated that for the maximally exposed individual, the chance of contracting leukemia as a result of exposure to fugitive benzene emissions would be within a range of 1.7×10^{-4} to 1.2×10^{-3} per lifetime.

Based on (1) the magnitude of benzene exposures from fugitive emission sources of benzene, (2) the resulting estimated maximum individual risks and estimated incidence of fatal cancers in the exposed population for the life of existing sources in the category, (3) the projected increase in benzene emissions as a result of new sources, (4) the potential to reduce significantly the risks and incidence by control requirements, and (5) consideration of the uncertainties associated with quantitative risk estimates (including the effects of concurrent exposures to other substances and to other benzene emissions), EPA found that fugitive emission sources of benzene pose a significant risk of cancer and warrant the establishment of a national emission standard under Section 112.

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[a] Drinking Water and Health, Part 1, Chapers 1-5, Draft, National Research Council, National Academy of Sciences, Washington, D.C., 1977 (Docket No. OAQPS-79-14-II-A-24).

[b] "General Criteria for Assessing the Evidence for Carcinogencity of Chemical Substances," Report of the Subcommittee on Environmental Carcinogenesis, National Cancer Advisory Board, Journal of the National Cancer Institute, 58:2, February, 1977 (Docket No. OAQPS-79-14-II-A-27).

[c] Hoel, David G., et al. "Estimation of Risks of Irreversible, Delayed Toxicity," Journal of Toxicology and Environmental Health 1:133-151, 1975 (Docket No. OAQPS-79-14-II-A-28).

Since the standard was proposed, EPA has revised the baseline benzene fugitive emissions estimate, the estimated emission reductions resulting from the standard, and the risk assessment for leukemia risk from benzene fugitive emissions. (See Section 2.8.2 of this document for a discussion of changes to the baseline and emission reduction estimates, and see Appendix C for complete descriptions of the revisions to the risk assessement). Benzene fugitive emissions are estimated to be 7,920 Mg/yr in 1980 in the absence of a benzene fugitive emissions standard. The promulgated standard is expected to reduce these emissions by approximately 69 percent. An estimated 20 to 30 million people live within 20 kilometers of existing process units that contain fugitive emission sources of benzene. This estimate changed since proposal because the revised risk assessment provides a better mechanism to determine the number of people that live within 20 kilometers of existing process units that contain fugitive emission sources of benzene. EPA has also calculated that, in the absence of a benzene fugitive emissions standard, the annual leukemia incidence would be about 0.45 cases per year within this population due to exposure to benzene fugitive emissions from existing sources. Further, EPA has estimated that for the maximally exposed group of people, the chance of contracting leukemia as a result of exposure to fugitive benzene emissions would be 1.5 x 10^{-3} per lifetime for existing sources.

These revised risk estimates are consistent with those that supported EPA's original determination at proposal. Thus, EPA continues to consider fugitive emission sources of benzene as a significant source category of benzene emissions for which risks and incidence can be reduced significantly.

As a means of evaluating the need for the standard, the commenters compare benzene fugitive emissions risk numbers with other types of regulated or commonly encountered risks. However, these comparisons must be used only with caution for several reasons. First, as described above, the benzene fugitive risk estimate and most other risk estimates, especially those dealing with carcinogens, low dosages, and varied atmospheric dispersion, contain considerable uncertainty. Second, the commenters ignore several important considerations by comparing the benzene fugitive emissions risk to background risk, commonly accepted risk, or risk addressed by other government regulations. Making value judgments about risk and comparing various risks should be performed only in the context of other factors that weigh in the decision making. These factors may include (1) whether the risk is undertaken voluntarily, (2) whether the effect will be immediate, (3) whether other alternatives are available, (4) whether the exposure is essential or a luxury, (5) whether the consequences are reversible, and (6) whether the risk is associated with a common or a "dread" hazard, such as nuclear holocaust or carcinogenesis. These factors seriously complicate any comparison of the absolute values of risk attached to different policies, activities, or technologies.

Congress writes legislation such as the Clean Air Act and implicitly sets priorities for government regulation of risks. In setting these priorities, Congress has found that it is not feasible to regulate every risky activity, technology, or event, but that it is desirable to regulate those significant risks that can be reasonably reduced. The congressional process directs priorities towards those risks that are most repugnant to the public. Ultimately, government agencies, through the Congressional process, are given regulatory authority; but these agencies are each likely to receive and, therefore, interpret their authority differently, thus addressing risk differently. Accordingly, EPA is required by Section 112 of the Clean Air Act to identify and regulate hazardous air pollutants. As described previously in this response, EPA has determined, based on risk and other factors, that benzene fugitive emission sources warrant federal regulatory action under Section 112.

The other commenter stated that the "risk levels that EPA has calculated are not 'significant' as that term has been used by the Court." EPA assumes that the commenter refers to the court interpretation in Industrial Union Department, AFL-CIO v. American Petroleum Institute, 65 L. Ed. 2d 1010, 100 S. Ct. 2844 (1980). This interpretation of the significance of risk was made in the context of The Occupational Safety and Health Act of 1970, not the Clean Air Act. It is not necessarily appropriate to transfer interpretations from one to the other. In any case, the Court in fact never indicated what actually constitutes a "significant" risk except to give obvious examples of what constitutes plainly acceptable and plainly unacceptable risks. The Court stated: "If, for example, the odds are one in a billion that a person will die from cancer by taking a drink of chlorinated water, the risk clearly could not be considered significant. On the other hand, if the odds are one in a thousand that regular inhalation of gasoline vapors that are two percent benzene will be fatal, a reasonable person might well consider the risk significant and take appropriate steps to decrease or eliminate it" (48 LW 5034). The Court then stated that it was the duty of the OSHA Administrator to determine, using rational judgment, the relative significance of the risks associated with exposure to a particular carcinogen. EPA has determined that the risk from benzene fugitive emissions represents a significant risk. In consideration of this, and other factors as described above, EPA considers fugitive emission sources of benzene to be a significant source category of benzene emissions for which the risks and incidence can be reduced significantly.

Comment: Several commenters stated that regulation of benzene fugitive emissions duplicates existing federal and State regulations and guidelines. Several of these commenters asserted that fugitive emissions of benzene will be reduced under other air pollution programs required by the Clean Air Act. Two commenters stated that some SIP's involving NAAQS for ozone parallel EPA's proposed provisions for monitoring, leak repairs, recordkeeping, and reporting (IV-D-20; IV-D-30). One commenter noted that the Control Techniques Guideline provisions are expected to reduce existing fugitive emissions by about 60 percent, noting that 93 percent of fugitive emissions affected by the proposed standard emanate from sources in ozone nonattainment areas (IV-D-27). This same commenter added that new sources will be subject to the proposed VOC new source performance standard (NSPS) for synthetic organic chemical plants and refineries. Another commenter stated that 96 percent of the population exposure to benzene emissions from stationary sources is attributable to emission sources in ozone nonattainment areas (IV-D-18). This commenter noted that most, if not all, of these areas will be subject to VOC fugitive emission control requirements imposed by the 1979-1980 SIP revisions which become effective prior to 1982.

Several commenters asserted that benzene fugitive emissions are already adequately controlled under existing OSHA regulations. One commenter felt that the implementation of the OSHA standard in conjunction with SIP's should be sufficient for effective control of benzene fugitive emissions (IV-D-20). One commenter contended that emissions covered by the standard will impact the workplace before any ex-plant environmental exposures are encountered, and the emissions must, therefore, be controlled to meet OSHA rules (IV-D-24). The same commenter noted that the Supreme Court decision on OSHA's proposed benzene workplace exposure limit change highlighted the validity of the present workplace limit (IV-D-24). Another commenter referred EPA to comments on the SOCMI VOC fugitives standard, dated March 26, 1981 (EPA docket item number A-79-32-IV-D-6). The commenter stated that the engineering controls considered by OSHA are identical to those described by EPA in the SOCMI VOC fugitives background information document.

Response: EPA has decided to regulate emissions of benzene under Section 112 of the Clean Air Act (42 FR 29332). Given this decision, EPA considered this comment in the context of whether EPA should select the alternative of taking no action to regulate benzene fugitive emissions and relying instead upon the OSHA standard for benzene, State implementation plans (SIP's) that control VOC emissions, and the proposed standards of performance for fugitive emission sources of VOC within the synthetic organic chemical manufacturing industry and within petroleum refineries. However, after considering this alternative, EPA concluded that reliance on this alternative would not be a reasonable approach to reducing emissions of benzene, a hazardous pollutant within the meaning of the Clean Air Act.

EPA believes that reliance on the OSHA standard is an unreasonable approach to reducing public risks associated with fugitive emissions of benzene. The OSHA benzene standard limits worker exposure to benzene. Many of the techniques used to attain the OSHA benzene standard include indirect emission controls such as process modifications, worker rotations, process or worker isolation, ventilation controls, modification of work practices, and emissions dilution. These techniques allow benzene emissions away from the workplace to remain uncontrolled, or to be removed only from the workplace without requiring that they be removed from the ambient air. Therefore, EPA concluded that this approach would protect public health inadequately.

EPA decided against relying upon SIP's to control VOC emissions from existing plants because not all existing plants are located in NAAQS nonattainment areas. Furthermore, those that are located in nonattainment areas might only be required to control emissions using reasonably available control technology (RACT) rather than the promulgated standard which provides additional emission reductions at reasonable costs. In its revised baseline as discussed in Section 2.8.2, EPA included emissions from petroleum refineries in NAAQS nonattainment areas, which are reduced by implementing controls specified in the petroleum refinery VOC control techniques guideline (CTG) document. EPA determined that the standards of performance under Section 111 for SOCMI and refinery fugitive VOC emissions might also be inadequate for controlling existing sources of benzene fugitive emissions. These standards will not apply to existing units and, therefore, would not result in emission reductions to the same extent as the promulgated standard. Therefore, EPA concluded that this approach would protect public health inadequately. (Also see Section 3.5.1 of EPA 450/5-82-003.)

Next, EPA reviewed the problems that might result from any redundancy or duplication of effort required by these different approaches. As a result of this review, EPA determined that the only problem might be associated with redundant and duplicative recordkeeping and reporting.

This problem could only occur for sources covered by the Clean Air Act. EPA has eliminated this problem within Section 61.110(b) of the proposed benzene fugitive emissions standard by eliminating any dual recordkeeping and reporting between the benzene fugitive emission standard and the standards for SOCMI and petroleum refinery emission sources of VOC. Similarly, any records and reports that are required by the States would be accepted by EPA as long as they contain at least the information required in the promulgated standard. The OSHA and benzene fugitive emission standards require no duplication of effort. Duplication between the benzene fugitive emission standard and the SIP regulations is similarly nonexistent. Where two regulations cover the same fugitive emission source, the owner or operator will simply comply with the more stringent of the two regulations and thereby comply with both. The owner or operator would not be required to install two sets of control devices or to perform two separate leak detection and repair programs for the same units.

Comment: One commenter asserted that the fugitive benzene proposal seems premature because it addresses less than 4 percent of the health problem perceived by EPA, while the most significant sources of health risk identified by the EPA, for example, "urban exposures" and automobile emissions, have not yet been addressed directly by rule, regulation, or standard (IV-D-18).

One commenter stated that the incidental exposure to benzene from fueling gasoline-powered engines (0.5 to 2 percent benzene) would probably exceed the concentration of benzene from a refinery (IV-D-10).

One commenter stated that regulation of benzene fugitive emissions under authorities other than Section 112 would be more logical. For example, since more than 80 percent of benzene emissions come from mobile sources not subject to Section 112, it would seem appropriate to regulate benzene under the National Ambient Air Quality Standards (IV-F-1).

Response: The main issue in these comments concerns whether to regulate mobile source-related benzene emissions. Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

In any case, EPA's determination that benzene fugitive emissions are a significant source category is an issue completely separate from the issue of whether or not mobile sources or other sources are regulated. As described in the response to the previous comment, EPA has determined that fugitive emission sources of benzene are a significant source category of a hazardous air pollutant and thus require the establishment of a national emission standard under Section 112 of the Clean Air Act.

Comment: One commenter cited the 24-unit SOCMI fugitive emissions study* to state that using EPA's own emission estimating technique along with the most recent data specific to the chemical industry, benzene fugitive emissions are already at a level for Alternative III in the proposed regulation for existing sources, which the Administrator has determined will provide the ample margin of safety required in Section 112 (IV-F-1, IV-D-21). In addition, one commenter stated that there are very little reliable data on actual uncontrolled benzene fugitive emissions, thus casting further doubt on the Agency's having met its statutory requirements of demonstrating significant risk from benzene exposure as a basis for the proposed NESHAP's (IV-K-1).

Response: In selecting Regulatory Alternative III, EPA did not determine that the residual risk was deemed acceptable in absolute terms. Rather, EPA proposed Regulatory Alternative III for existing sources in light of the exorbitant additional incremental costs that would be required to further reduce the risk. EPA first identified the best available technology (BAT), considering environmental, economic, and energy impacts, to control fugitive emission sources of benzene from the various regulatory alternatives considered. EPA then examined the residual risks due to benzene emissions remaining after application of BAT to determine whether or not they are unreasonable in view of the risk reduction that would be gained by requiring a level of control beyond BAT and the associated increase in costs.

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*U.S. EPA, Office of Research and Development (ORD). "Frequency of Leak Occurrence for Fittings in Synthetic Organic Chemical Plant Process Units." EPA 600/2-81-003. September 1980. Docket Number A-79-27-II-A-34.

Therefore, the determination of whether or not residual risks are unreasonable was contingent upon the incremental costs associated with additional reductions of emissions.

In reanalyzing the impacts of the proposed standard, EPA continues to use petroleum refinery data to estimate uncontrolled benzene emissions. As discussed in Section 2.8.4, new data developed in the SOCMI fugitive emissions study and associated with equipment in benzene service do not estimate emission factors for all types of benzene-service equipment and, thus, are insufficient for direct estimation of benzene emissions. Additionally, these data were not gathered for the purpose of generating emission factors. The petroleum refinery data base used at proposal of the standard, however, was gathered to determine VOC emission factors for all leak sources. EPA still considers, therefore, the controls proposed under Regulatory Alternative III to be effective in reducing emissions from fugitive emission sources of benzene.

The third commenter (IV-K-1), in a separate comment on the data base, explained in greater detail the basis for the comment on data specific to fugitive benzene emissions. The summary of this detailed version and EPA's response are found in Section 2.8.4 of this document.

Comment: One commenter ran through a series of calculations concluding that the actual average individual lifetime leukemia risk is equal to, or less than, 2.05×10^{-9}, or two chances in one billion, that an individual will contract leukemia as a result of benzene fugitive emissions. The commenter arrived at this lower estimate by using altered assumptions that changed two factors in the calculation: First, the commenter lowered the EPA Carcinogen Assessment Group's unit risk factor by one order of magnitude. Second, the commenter lowered EPA's estimate of baseline emissions by 60 percent to account for CTG regulatory impacts (IV-D-27).

Response: EPA uses maximum lifetime risk as one of the risk criterion for selecting source categories and levels of emission control. However, the commenter computed the average lifetime risk, which is not comparable to maximum lifetime risk.

EPA questions the validity of the commenter's assumptions relating to the unit risk factor. EPA has discussed the commenter's assumptions about the baseline emissions estimate in Section 2.8.2 of this document and has responded to the comment about the unit risk factor in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

2.1.3 Standard is Overdue

Comment: One commenter supported the prompt issuance of final standards, noting that the standard is long overdue since it should have been set within a year of the June 1977 listing of benzene as a hazardous air pollutant (IV-D-31).

Response: Standards development can be a long and complex task. EPA attempted to set this standard in a quality and timely fashion. Accordingly, several years passed since June 1977 before the standard was proposed and now the standard is being promulgated.

2.1.4 Clean Air Act Authority for EPA to Set Control Requirements

Comment: One commenter felt that EPA lacks the authority to water down the control requirements of Section 112. The commenter agreed with EPA's contention that since no threshold exposure can be defined for carcinogens, no level of exposure can be considered safe. Since there is no safe level of exposure, the commenter noted, Section 112 of the Clean Air Act establishes a goal of eliminating benzene emissions. According to the commenter, best demonstrated technology is inadequate for this task and should be replaced in a technology-forcing fashion by "best performing technology," including transfer technology (IV-D-31).

Response: Response to this comment can be found in Appendix D, General Policy.

2.1.5 Authority for Risk-Benefit Analysis

Comment: One commenter asserted that EPA lacks the authority to engage in risk-benefit analyses as it has in the benzene fugitive proceedings. According to the commenter, Congress has consistently rejected risk-benefit analysis as having no place in the Clean Air Act; furthermore, there is no place in the Act where risk-benefit analysis is less consistent with the statutory language and intent than Section 112, with its directive to set standards that protect health with "an ample margin of safety" (IV-D-31).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

2.1.6 Ability to Quantify Margin of Safety

Comment: According to the commenter, Congress recognized that under the current state of scientific knowledge, an ample margin of safety cannot be quantified. The commenter stated that Congress did not require EPA to delay regulation until this precise quantification was possible, nor did Congress force EPA to undertake "sham" quantitative risk analyses (IV-D-31).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act, in discussing the use of quantitative risk assessment.

2.1.7 Suspension of Benzene Proceedings

Comment: Several commenters maintained that EPA should temporarily suspend or postpone proceedings on the benzene source-specific standards until EPA makes final decisions on the listing of benzene (IV-F-1; IV-D-19; IV-D-25; IV-D-28; IV-D-3). One commenter noted that a brief suspension of the proceedings will not result in undue delay (IV-D-3).

Response: EPA believed that a suspension or delay of the standard was unnecessary. The standard development process takes enough time that any issues arising with respect to the listing of benzene have ample time to be reviewed and resolved before the standard is promulgated. In addition, Section 112 requires that EPA promptly establish national emission standards for hazardous air pollutants.

2.2 HEALTH EFFECTS AND RISK ASSESSMENT OF BENZENE EXPOSURE

Several commenters criticized the methods EPA used to estimate risk from fugitive benzene emissions. Some commenters felt that EPA had overestimated risk. One felt that EPA had underestimated it. These and other related comments are summarized below.

2.2.1 Overestimation of Risk

Several commenters felt that EPA had overestimated the risk from fugitive benzene emissions. Two common reasons were given for EPA's overestimation of risk: (1) that the EPA Carcinogen Assessment Group (CAG) overestimated the benzene dose-response relationship; and (2) that

EPA's exposure assessments are flawed by inadequate data and unnecessary or inaccurate assumptions. These comments are summarized below.

2.2.1.1 Dose-Response. Comment: Two commenters stated that EPA's assumption that leukemia risk can be extrapolated from high doses to very low doses is not justified by available direct evidence (IV-D-27; IV-D-29). One of the commenters believed that the linear dose-response model is the most conservative method that could be applied to the data, and it results in an upper-limit estimate of the leukemia risk for benzene. The commenter contended that available empirical evidence suggests the absence of health effects below 10 parts per million. According to the commenter, EPA notes that benzene has been connected with other adverse health effects, such as pancytopenia, aplastic anemia, chromosome changes, and reproductive effects; but the commenter contends that these effects result only from exposures in excess of 10 parts per million. Moreover, the commenter adds there is no direct evidence that benzene is carcinogenic or leukemogenic at levels below 100 parts per million. The commenter noted that EPA estimated that maximum benzene exposures would be only in the very low parts per billion range, and average exposure within 20 kilometers of the source would be only 19 parts per trillion. The commenter feels that no leukemia risk can be substantiated at these low levels of exposure (IV-D-27).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

Comment: One commenter noted that, in its ruling on OSHA's reduction of allowable occupational exposure to benzene from 10 ppm to 1 ppm, the U.S. Supreme Court in 1980 determined that OSHA "made no finding that the Dow study, or any other evidence, or any opinion testimony demonstrated that exposure to benzene at or below the 19 ppm level had ever in fact caused leukemia." According to the commenter, EPA has based its evaluation of public exposure to benzene storage vessels on an estimated maximum out-of-plant concentration of 18.7 parts per billion, significantly below the levels addressed in the OSHA proceedings.

The commenter acknowledged that there is some epidemiologic data which appear to support an association between leukemia and benzene at high concentrations. However, the commenter added that the leukemogenic action of benzene at these high levels is preceded by blood changes, such as cytopenia and pancytopenia, and that these pre-leukemic changes do not occur at levels below about 35 ppm. According to the commenter, one study of benzene-exposed pliofilm rubber workers which allegedly found excess leukemia at low levels turned out to have underestimated the exposure, which in fact substantially exceeded 100 ppm. In two other epidemiologic studies, one on petroleum workers exposed to benzene and one on benzene-exposed chemical workers, the commenter noted that no excess leukemia was found. As the commenter stated, the exposures in the latter two groups, although not precisely quantifiable, were clearly much greater than the nonoccupational exposures in the community (IV-D-24). Another commenter made a similar general statement (IV-F-1).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act, and in the background document for benzene emissions from benzene storage tanks (EPA-450/3-80-034b).

Comment: One commenter maintained that the EPA has overestimated the benzene risk factor by an order of magnitude. The commenter noted that a valid risk factor for benzene exposure, which was developed by Dr. Steven Lamm and confirmed by Dr. Richard Wilson, is 0.031×10^{-6} cases per year per person-ppb-year, whereas the EPA has utilized a factor of 0.34×10^{-6} cases per year per person-ppb-year. According to the commenter, taking the valid factor into account, a maximum of only two cases would be anticipated (nationwide) due to 20 years of exposure to existing benzene fugitive emissions. Utilizing EPA's assumption of an overall efficiency of emission control of 77 percent, the commenter concluded that this regulation would save 77 percent of from 0.3 to 2.1 people or 1 person (IV-D-24).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

Comment: One commenter observed that the CAG risk factor was overestimated because CAG misinterpreted the results of the three epidemiological studies used in the analysis. According to the commenter, one of the studies showed no statistically significant increase in leukemia incidence, and those leukemias that did occur were only doubtfully related to benzene exposure. The commenter asserted that CAG's analysis of the other two studies overstated the relative leukemia risk by overcounting leukemia incidence in the study population, underestimating leukemia incidence in control populations, and underestimating the concentration of benzene to which study groups were exposed. As a result, the commenter concluded that the CAG risk factor overstated the exposure risk by at least an order of magnitude (IV-D-27).

Response: Response to this comment can be found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

2.2.1.2 Exposure Assessment. Comment: Two commenters stated that the model plant methodology used by EPA overestimates risk from benzene exposure. The commenters suggested that a more realistic and accurate risk estimate would be obtained using actual plant emission data, actual population data, and available plant-specific emission data (IV-D-27; IV-F-1).

One commenter maintained that EPA's benzene fugitive emissions exposure analysis relied upon incomplete and inaccurate meteorologic data. Rather than use site-specific climatological data as required by EPA guidelines, the commenter remarked that the analysis relies entirely on conditions in Houston to apply to refineries and chemical plants in 23 States and territories, from New York to California. According to the commenter, EPA concedes that this assumption causes an overstatement of estimated exposure, noting its data were "representative of poor dispersion conditions in the area in order to develop a potential worst-case situation." The commenter concluded that since climatological data for approximately 300 sites throughout the U.S. are available in EPA archives, EPA's total reliance on Houston meteorology was not justified (IV-D-27). The commenter also stated that EPA arbitrarily oriented the fugitive emission sources of a hypothetical model refinery in order to maximize the ambient concentrations at the plant boundary. According to the commenter, this was done despite the fact that the actual location of emission sources at the Sauget, Illinois, plant could easily be ascertained (IV-D-27).

One commenter asserted that EPA failed to validate the results of its air quality modeling as a check on its accuracy, as required by EPA guidelines. According to the commenter, in this exposure analysis, EPA repeatedly has relied upon unsupported assumptions about emissions, meteorology, population distribution, and other factors, even though accurate data were readily available. The approach taken resulted in an unacceptably high degree of uncertainty in EPA's exposure estimates; in some instances, the exposure estimate may be off by a factor of 100 or more (IV-D-27).

Response: The commenter is correct in noting that the benzene fugitives risk assessment did not make use of plant-specific data relating to emissions, meteorology, or plant configurations. However, as explained below, the plant-specific approach probably would not improve the precision or accuracy of the results enough to justify the level of effort to use more specific data. EPA has concluded that a plant-specific approach would be too costly and not necessary for benzene fugitive emission sources. In response to this comment, EPA has revised its original risk assessment for benzene fugitive emissions. Even though the revised risk assessment methodology has changed since proposal, it is similar to the one used at proposal. The revised risk assessment methodology is described in Appendix C. The revised methodology uses an improved calculation technique and input values. For example, the unit risk factor has been recalculated; there is a new baseline emission estimate (see Section 2.8.2); different plants are included in the data base; there are new emission reduction estimates (see Section 2.8.2); and better population and meteorology data have been used.

EPA considered the option of using plant-specific data for all parameters in order to run an exposure model for each plant. EPA considered the uncertainty that would result using the plant-specific data approach with the uncertainty that would result using the model plant and extrapolation approach. EPA also considered the level of effort that would be required to complete the two options.

The plant-specific approach probably would not improve the precision or accuracy of the results enough to justify the level of effort required to gather the input data. Of course, the use of more precise and accurate data allows better results to be calculated. However, a plant-specific approach would entail using "Section 114" letters to gather plant information on emissions, meteorology, and plant configuration from about 130 plants. This would require substantial effort from plant owners as well as from EPA. The dispersion and exposure models would then have to be run about 390 times, at least three times for each plant. The resultant increase in precision and accuracy would probably be small compared to the uncertainty (still remaining) that is inherent in the dispersion and exposure models and in the input data used. Both the Industrial Source Complex Long Term computer model (ISC-LT) and the Human Exposure Model, even with perfect input data, are subject to substantial uncertainty. (The ISC-LT model, even with state-of-the-art input data, is estimated to have a 95 percent confidence interval of plus or minus a factor of two.)

EPA has not exaggerated the precision of the results of the model plant extrapolation method, nor has EPA attempted to refine the results of the model plant extrapolation method any more than is warranted by the quality of the data and the modeling technique. Uncertainties are clearly delineated (see Section 2.1.2 of this document). The results are presented in highly aggregate, nonspecific terms, in a fashion that exhibits much less uncertainty than if EPA tried to squeeze more detailed, refined results from the extrapolation. Using the model plant extrapolation method, less accurate deviations in the results for specific plants tend to average out when the total national incidence is computed. Attempting to validate the results of the air quality modeling would require an extremely detailed, burdensome, and costly plant-specific approach. Because a plant-specific approach would be very costly and would not substantially improve upon the precision and accuracy already achieved by the model plant extrapolation approach, EPA has elected to use the model plant extrapolation approach.

Comment: One commenter noted that the risk estimate used by EPA assumed no government regulation of benzene fugitive emissions, while in fact the vast majority of such emission sources will be required to reduce emissions by State implementation plans for ozone. According to the commenter, approximately 93 percent of the risk from fugitive benzene emissions comes from sources in ozone nonattainment areas. These sources will be subject to emission control requirements at least as stringent as those contained in EPA's control techniques guidelines (CTG's) for refineries and synthetic organic chemical plants. The commenter notes that EPA concedes that these requirements will reduce benzene emissions by 60 percent (IV-D-27).

Response: In its revised risk assessment (see Appendix C of this document), EPA has used a new baseline for benzene fugitive emissions that accounts for emission reductions that will be achieved in 1982 as a result of refinery CTG control requirements (see Section 2.8.2 of this document for discussion of the new baseline). CTG control requirements are incorporated in the State implementation plans. Petroleum refining units in nonattainment areas in 1982 are assumed to be implementing CTG controls. All other units are assumed to have uncontrolled emissions. EPA expects that CTG controls will reduce total national fugitive benzene emissions in 1985 from the uncontrolled level by about 8 percent. The CTG control requirements are included in the baseline estimate of risk.

Comment: One commenter added that deficiencies exist in the population concentration estimates contained in the exposure analysis. According to the commenter, EPA assumed that population is distributed uniformly in all directions at each site, which introduces an uncertainty factor of 10 to 100 into the overall exposure estimate (IV-D-27).

Response: EPA's revised risk estimate (see Appendix C) was based upon a more sophisticated population exposure model, which utilized a population data base characterized as having a high level of resolution. The Human Exposure Model (HEM) was used to estimate the population that resides in the vicinity of each receptor coordinate surrounding each plant. The HEM does not assume population is distributed evenly around each plant. The population "at risk" to benzene exposure was considered to be persons residing within 20 km of the plants. The population around each plant was determined by specifying the geographical coordinates of that plant.

A slightly modified version of the "Master Enumeration District List--Extended (MED-X)" data base, a Census Bureau data base, is contained in the HEM and used for population pattern estimation. This data base is broken down into enumeration district/block group (ED/BG) values. MED-X contains the population centroid coordinates (latitude and longitude) and the 1970 population of each ED/BG in the United States (50 States plus the District of Columbia). For human exposure estimations, MED-X has been used to produce a randomly accessible computer file of only the data necessary for the exposure estimation. A separate file of county-level growth factors, based on the 1970 to 1980 growth factor at the county level, has also been created for use in estimating 1980 population figures for each ED/BG.

The plant's geographical coordinates and the concentration patterns computed by the model plant extrapolation method were used as input to the HEM. For each receptor coordinate, the concentration of benzene and the population estimated by the HEM to be exposed to that particular concentration are identified. The HEM multiplies these two numbers to produce population exposure estimates and sums these products for each plant. A two-level scheme has been adopted in order to pair concentrations and populations prior to the computation of exposure. The two-level approach is used because the concentrations are defined on a radius-azimuth (polar) grid pattern with nonuniform spacing. At small radii, the grid cells are generally much smaller than ED/BG's; at large radii, the grid cells are much larger than ED/BG's. The area surrounding the source is divided into two regions, and each ED/BG is classified by the region in which its centroid lies. Population exposures are calculated differently for the ED/BG's located within each region.

For ED/BG centroids located between 0.1 km and 2.8 km from the emission source, populations are divided between neighboring concentration grid points. There are 96 (6 x 16) polar grid points within this range. Each grid point has a polar sector defined by two concentric arcs and two wind direction radials. Each of these grid points is assigned to the nearest ED/BG centroid identified from MED-X. The population associated with the ED/BG centroid is then divided among all concentration grid points assigned to it. The exact land area within each polar sector is considered in the apportionment.

For the population centroids between 2.8 km and 20 km from the source, a concentration grid cell, the area approximating a rectangular shape bounded by four receptors, is much larger than the area of a typical ED/BG (usually 1 km in diameter). Since there is a linear relationship between the logarithm of concentration and the logarithm of distance for receptors more than 2 km from the source, the entire population of the ED/BG is assumed to be exposed to the concentration that is geometrically interpolated radially and arithmetically interpolated azimuthally from the four receptors bounding the grid cell. Concentration estimates for 80 (5 x 16) grid cell receptors at 2.0, 5.0, 10.0, 15.0 and 20.0 km from the source along each of 16 wind directions are used as reference points for this interpolation.

In summary, two approaches were used to arrive at coincident concentration/population data points. For the 96 concentration points within 2.8 km of the source, the pairing occurs at the polar grid points using an apportionment of ED/BG population by land area. For the remaining portions of the grid, pairing occurs at the ED/BG centroids themselves, through the use of log-log and linear interpolation.

Comment: One commenter stated the analysis failed to account for population activity patterns and population mobility, thereby overestimating exposure levels for persons residing in the affected area surrounding these plants (IV-D-27).

Response: As discussed in Section 2.1.2, there are several uncertainties associated with exposure assessments. One of these uncertainties concerns population activity patterns and mobility.

While EPA's exposure assessment does not account for people moving into or out of this area, there is no reasonable way to know if the maximum exposed persons actually leave the area. In light of all of these factors, EPA has concluded that its exposure assessment is still a useful tool.

Comment: One commenter criticized EPA's estimate of "maximum individual lifetime risk" by noting that EPA has no evidence that any individual ever lives an entire lifetime 0.1 kilometers from the plant at a point of maximum benzene concentration (IV-D-27).

Response: Response to this comment can be generally found in EPA-450/5-82-003, which was prepared to address the listing of benzene under Section 112 of the Clean Air Act.

The maximum individual lifetime risk, as the commenter understood, is the risk associated with exposure to the maximum concentrations. Maximum concentrations are only modeled estimates and may overestimate or underestimate the actual concentrations. As discussed in docket item IV-B-18, the maximum concentrations and, consequently, the maximum individual lifetime risks (which were estimated and used to make, to the limited extent they were used, decisions) appear to be underestimates. Provided the air at 0.1 kilometer from plant is located in a neighborhood, the opportunity for exposure exists. Using the HEM, exposures to maximum concentrations are generally limited to distances greater than 0.2 kilometer and to locations where people reside. In the absence of perfect information regarding the magnitude and deviation of exposure, it is prudent to assume that, as a "maximum," an individual could face continuous exposure to a maximum concentration.

2.2.2 Underestimation of Risk

Comment: One commenter felt that EPA had understated the risk of exposure to benzene fugitive emissions. According to one commenter, the scientific knowledge necessary for reasonably reliable and precise estimates of human cancer risks simply is not available. The commenter felt that, given interactions and synergisms, it is much more likely that exposure to multiple chemicals will have an additive or multiplicative effect than that such chemicals will cancel each other out. This commenter cited many sources of uncertainty in the risk assessment and concluded that EPA may have drastically understated the real leukemia risk associated with benzene. According to the commenter, the estimates given by EPA at proposal may well underestimate the health benefits of the increment between the proposed requirements and use of vapor recovery or thermal destruction of emissions. The commenter added that it is unacceptable that the noncarcinogenic effects of benzene exposure have virtually dropped out of EPA's analysis due to the fact that they cannot be readily quantified. According to the commenter, the proposal makes no efforts to see that these effects get appropriate weight in the decision to stop short of Regulatory Alternatives IV or V, in favor of Alternative III (IV-D-31).

Response: EPA considered this comment in the light of the decision to promulgate a standard for benzene fugitive emissions (equipment leaks of benzene). In the context of this standard, EPA estimated exposure to benzene fugitive emissions and concluded that these emissions warrant federal regulation under Section 112. In addition, EPA estimated exposure to these emissions after application of BAT and after application of more restrictive control and concluded that BAT is the appropriate level of control for this standard. These are the only uses of exposure assessment in this standard, and neither of these uses is affected by the commenter's contention that the exposure assessment underestimates leukemia risk.

While the commenter may be correct that interactions and synergisms (resulting from exposures to multiple chemicals) may be additive or multiplicative (or antagonistic) and therefore result in truly greater (or smaller) risks to persons exposed to benzene, EPA is unable to estimate these effects and, therefore, has not considered them. It should be noted that many of the factors used in making the exposure assessment have uncertainties associated with them and that these uncertainties can result in underestimation as well as overestimation. These uncertainties have been considered as much as practicable by EPA in setting this standard. EPA, aware of these uncertainties, used the exposure assessment in the two ways described above in a reasonable manner to establish this standard.

Comment: One commenter noted that EPA assumed that many benzene-emitting facilities have a life expectancy of 50 years or more. Yet the quantifications of risk used to compare the proposed approach with a more protective one assume a 20-year lifetime. According to the commenter, this understates the number of benzene victims for such facilities by two and one-half times or more, and reconsideration of the decision not to adopt Alternatives IV or V with the appropriate health effects timeframe may lead to a different decision (IV-D-31).

Response: Twenty years is an average figure for the lifetime of a plant. Some plants have a life expectancy of 50 years; some have lifetimes shorter than 20 years. Roughly, a plant will have a lifetime of 20 years. Since there are little data available that estimate plant lifetimes, EPA considers 20 years to be a reasonable estimate. The length of the lifetime of plants using or producing benzene, however, was not a factor considered in selecting the final standard.

2.2.3 Consistency in Methodologies

Comment: Two commenters stated that there should be some consistency in risk assessment methodologies between the four current benzene proposals (IV-D-8; IV-D-24). One commenter stated that if benzene is to be regulated by a NESHAP standard, the emission concerns and risk/benefit analysis should be completed for all types of emissions (e.g., process emissions, storage tank emissions, fugitive emissions, etc.) simultaneously. This integrated analysis, the commenter maintained, would prevent duplication of effort, errors, or inconsistencies and result in an overall analysis of the risk/benefit of a product. According to the commenter's review of the four current benzene proposals, a great deal of duplication has occurred with little or no health benefit to the public (IV-D-24).

Response: EPA has tailored the risk assessment methodologies among the four benzene standards to be as consistent as practical. However, an integrated analysis is not feasible, and thus some duplication is unavoidable. Primarily due to the large numbers of plants, it is not feasible for the fugitive benzene emissions or benzene storage risk assessments to achieve the same degree of detail and precision as was achieved in the maleic anhydride or ethylbenzene/styrene (EB/S) risk assessments. The maleic anhydride and EB/S assessments calculated risk separately for each of 8 and 15 plants, respectively, using plant-specific data supplied voluntarily by the plants as part of their public comments. The benzene fugitives and benzene storage data bases contain about the same number of plants. To supply plant-specific data on emissions, meteorological data, and plant configuration would require that these plants implement a leak detection and repair program, monitor meteorological conditions, and inventory detailed specifics on plant configuration. As described in a previous comment in Section 2.2.1.2, EPA believes that such an effort is unreasonably costly and unnecessary.

Comment: One commenter noted that the exposed population cited in this regulation was 65 million persons, while the exposed population cited for benzene emissions from benzene storage vessels was 85 million persons. Since the population sizes are based on fixed size areas surrounding benzene producers and users facilities, they should be identical. According to the commenter, the concentration outside the plant boundary may differ for the two emission sources, but the populated area surrounding the plant should not (IV-D-24).

Response: The commenter is correct in observing that the exposed population in the two risk assessments should be the same. As a result of revisions to the risk assessments made since proposal, EPA has adjusted this figure to read that 20 to 30 million persons will be exposed to benzene emissions from either fugitive emission sources or benzene storage vessels.

2.3 SELECTION OF THE FINAL STANDARD

Comment: Many people commented on the basis for selection of the proposed standard. Several commenters questioned the cost effectiveness and impacts of Regulatory Alternatives III and IV for existing and new sources, respectively. Some of the commenters recommended the selection of less stringent regulatory alternatives, and some recommended the selection of a more stringent regulatory alternative. Other commenters stated that selection should be based on the cost and emission reduction impact of each control technique rather than regulatory alternatives.

Response: After considering these comments, EPA selected the final standards for new and existing equipment in benzene service. Selection of the basis of the final standard was a two-step process and was similar to the approach used when the standard was proposed. The first step was the selection of the best available technology (BAT). Best available technology for new and existing equipment in benzene service is technology which, in the judgment of the Administrator, is the most effective level of control considering economic, energy, and environmental impacts and any technological problems associated with the retrofitting of existing equipment. After consideration of these impacts for each alternative control technique, one set of control techniques was selected as BAT for new and existing equipment in benzene service.

After selecting certain control techniques as BAT, EPA evaluated the estimated health risks remaining after application of BAT to determine if they are unreasonable in view of health risk reductions and cost (economic) impacts that would result if the next more stringent level of control were applied. This provides a comparison of the costs and economic impacts of control with the benefits of further risk reduction. The benefits of risk reduction are expressed in terms of the estimated leukemia incidence within 20 kilometers of the equipment covered by the standard and the estimated maximum lifetime risk at the point of maximum exposure. The results of this comparison determine whether, in the judgment of the Administrator, the residual risks remaining after application of BAT are unreasonable. If the risks remaining after application of BAT are judged to be unreasonable, further controls would be required.

The costs of the control techniques for benzene equipment leaks are very small relative to the capital and operating costs of affected process units. As a consequence, none of these control techniques impacts the ability of an owner or operator to raise capital or measurably impact product prices or energy requirements. Therefore, EPA selected BAT primarily based on a comparison of costs and emission reductions associated with each alternative control technique. In making this decision, EPA is accepting the suggestions of commenters to consider further cost per unit emission reduction estimates and to consider these estimates for each type of equipment covered by the standard in the selection of BAT. In selecting BAT, EPA initially selected control techniques that achieve the greatest emission reduction with reasonable control costs per megagram of emission reduction. The emission reductions and the average and incremental costs per megagram of benzene and total emissions (including benzene and other volatile organic compounds (VOC)) are summarized in Tables 2-2 and 2-3, respectively, for each type of equipment covered by the standard. After initially selecting one set of control techniques as BAT for each type of equipment covered by the standard, EPA analyzed economic and other impacts of this set of control techniques. To the extent that these impacts were reasonable, the control techniques were selected as BAT and then were used in estimating the risks remaining after application of BAT.

For each type of equipment, the average cost effectiveness of each control technique was calculated based on the net annualized cost and the annual emission reduction from the uncontrolled level. Starting with the most stringent control technique, which achieves the greatest emission reduction at the greatest annualized cost, EPA examined the incremental cost effectiveness between the most stringent control technique and the next less restrictive control technique. The incremental cost effectiveness between any two alternative control techniques was based on the difference in net annualized costs divided by the difference in the annual emission reductions of the alternate control techniques. If the incremental cost in comparison to the incremental emission reduction is judged unreasonable, then the next increment is examined until a control technique with a reasonable incremental cost in comparison to the incremental emission reduction is available.

Costs per megagram of emission reduction (average and incremental) were calculated in terms of total emissions (benzene and other VOC) as well as benzene alone. Control of benzene equipment leaks

Table 2-2. CONTROL COSTS PER MEGAGRAM OF BENZENE REDUCED[a]

Type of Equipment	Control Technique	Benzene Emission Reduction[b] (Mg/yr)		Average $/Mg Benzene[c]		Incremental $/Mg Benzene[d]	
		New	Existing	New	Existing	New	Existing
Valves	Annual leak detection and repair	162	799	--[e]	--[e]	--[e]	--[e]
	Quarterly leak detection and repair	639	2,750	--[e]	--[e]	--[e]	--[e]
	Monthly leak detection and repair[f]	736	3,160	--[e]	--[e]	210	120
	Sealed bellows valves	998	4,280	8,500	11,000	33,000	44,000
Pumps	Annual leak detection and repair	77	290	870	870	870	870
	Quarterly leak detection and repair	266	959	--[e]	--[e]	--[e]	--[e]
	Monthly leak detection and repair[f]	307	1,140	--[e]	--[e]	--[e]	--[e]
	Dual mechanical seal systems	372	1,360	2,100	2,400	13,000	15,000
Compressors	Degassing reservoir vents[f]	3.5	--[h]	--[e]	--[h]	--[e]	--[h]
Pressure Relief Devices	Quarterly leak detection and repair[i]	53	190	--[e]	--[e]	--[e]	--[e]
	Monthly leak detection and repair[i]	58	207	--[e]	--[e]	300	290
	Equipment control[f,i]	82	295	96	180	1,400	1,700
Open-ended Lines	Caps on open ends[f]	54	187	430	470	430	470
Sampling Connection Systems	Closed-purge sampling[f]	87	318	880	900	880	900
Product Accumulator Vessels	Closed-vent system[f]	27	106	94	97	94	97

Table 2-2. CONTROL COSTS PER MEGAGRAM OF BENZENE REDUCED[a]

(concluded)

[a] Costs and emission reductions are presented on a nationwide basis and are derived from Docket Item IV-B-14.

[b] Benzene emission reductions are presented on a nationwide basis as explained in Docket Item IV-B-14.

[c] Average dollars per megagram (cost effectiveness) = net annualized cost ÷ annual benzene emission reduction. These cost-effectiveness numbers can be calculated on a component basis, on a model unit basis, or on a nationwide basis. In any case, the resulting cost effectiveness will be essentially the same. The numbers in this table have been calculated on a nationwide basis by multiplying the net annual cost per component (BID Tables A-1 through A-11) by the total number of components nationwide (BID Tables 2-6 and 2-7) and then dividing the resulting nationwide net cost by the nationwide emission reduction, as explained in Docket Item IV-B-14.

[d] Incremental dollars per megagram = (net annualized cost of the control technique - net annualized cost of the next less restrictive control technique) ÷ (annual benzene emission reduction of control technique - annual benzene emission reduction of the next less restrictive control technique).

[e] Dashes denote savings.

[f] Control technique selected as the basis for the final standard.

[g] Emission reduction associated with one new compressor.

[h] Existing compressors in benzene service are not known to exist; however if one does, the emission reduction and control costs per megagram of benzene would be the same as for a new compressor.

[i] Controls for pressure relief devices are based on the following: 75 percent of relief devices are already controlled. For the remaining uncontrolled sources, "equipment controls" means 75 percent of relief devices will be vented to a flare, 12.5 percent will be controlled by rupture disk/block valve systems, and 12.5 percent will be controlled by rupture disk/3-way valve systems.

Table 2-3. CONTROL COSTS PER MEGAGRAM OF TOTAL EMISSIONS REDUCED[a]

Type of Equipment	Control Technique	Total Emission Reduction[b] (Mg/yr)		Average $/Mg		Incremental $/Mg	
		New	Existing	New	Existing	New	Existing
Valves	Annual leak detection and repair	313	1,306	--[e]	--[e]	--[e]	--[e]
	Quarterly leak detection and repair	1,005	4,440	--[e]	--[e]	--[e]	--[e]
	Monthly leak detection and repair[f]	1,150	5,090	--[e]	--[e]	140	74
	Sealed bellows valves	1,540	6,960	4,900	6,900	20,000	26,000
Pumps	Annual leak detection and repair	124	468	540	540	540	540
	Quarterly leak detection and repair	413	1,560	--[e]	--[e]	--[e]	--[e]
	Monthly leak detection and repair[f]	484	1,830	--[e]	--[e]	--[e]	--[e]
	Dual mechanical seal systems	584	2,210	1,400	1,500	8,200	8,700
Compressors	Degassing reservoir vents[f]	5.5[g]	--[h]	--[e]	--[h]	--[e]	--[h]
Pressure Relief Devices	Quarterly leak detection and repair[i]	83	308	--[e]	--[e]	--[e]	--[e]
	Monthly leak detection and repair[i]	90	336	--[e]	--[e]	190	180
	Equipment control[f,i]	128	475	61	110	940	1,100
Open-ended Lines	Caps on open ends[f]	83	313	280	280	280	280
Sampling Connection Systems	Closed-purge sampling[f]	136	510	560	560	560	560
Product Accumulator Vessels	Closed-vent system[f]	42	171	60	60	60	60

Table 2-3. CONTROL COSTS PER MEGAGRAM OF TOTAL EMISSIONS REDUCED[a] (concluded)

[a] Costs and emission reductions are presented on a nationwide basis and are derived from Docket Item IV-B-14.

[b] Total emission reductions are estimated for benzene and other VOC and are presented on a nationwide basis as explained in Docket Item IV-B-14.

[c] Average dollars per megagram (cost effectiveness) = net annualized cost ÷ annual emission reduction. See Table 2-2, footnote c.

[d] Incremental dollars per megagram = (net annualized cost of the control technique - net annualized cost of the next less restrictive control technique) ÷ (annual emission reduction of the control technique - annual emission reduction of the next less restrictive control technique).

[e] Dashes denote savings.

[f] Control technique selected as the basis for the final standard.

[g] Emission reduction associated with one new compressor.

[h] Existing compressors in benzene service are not know to exist; however, if one does, the emission reduction and control costs per megagram of total emissions would be the same as for a new compressor.

[h] Controls for pressure relief devices are based on the following: 75 percent of relief devices are already controlled. For the remaining uncontrolled sources, "equipment controls" means 75 percent of relief devices will be vented to a flare, 12.5 percent will be controlled by rupture disk/block valve systems, and 12.5 percent will be controlled by rupture disk/3-way valve systems.

results in the destruction of other organic compounds (mainly VOC's) as well as benzene; therefore, control of VOC is an added benefit of controlling benzene. In making decisions about the acceptability of the cost of emission reductions achieved by a control technique, it is appropriate to consider the VOC as well as the benzene emission reductions. However, VOC emission reductions were considered only in the sense that VOC emission reductions can add weight to selecting a control technique as BAT.

The basis for selecting BAT for each type of equipment in benzene service is discussed below. It should be noted that the control costs for each type of equipment do not represent the actual amounts of money spent at any particular plant site. The cost of emission reduction systems will vary according to the chemical product being produced, production equipment, plant layout, geographic location, and company preferences and policies. However, these costs and emission reductions are considered typical of control techniques for benzene equipment leaks and can be used in selecting the level of control to be required by the standard.

Valves. EPA first considered the use of sealed bellows valves. However, a requirement for sealed bellows valves is considered unreasonable. The incremental cost for the use of sealed bellows valves compared to a monthly leak detection and repair program for valves is about $49 million/yr for existing valves and results in an emission reduction of about 1,100 Mg/yr of benzene; this represents an incremental cost effectiveness of about $44,000/Mg. Furthermore, the use of sealed bellows valves results in an incremental emission reduction of 1,870 Mg/yr of total emissions (including benzene and other VOC). Because the incremental cost effectiveness ($44,000/Mg of benzene) of this control technique is relatively high and because the additional emission reduction of VOC does not add enough weight to convince EPA that the costs are reasonable, EPA decided not to require the use of sealed bellows valves.

Next, EPA considered several leak detection and repair programs for valves. The leak detection and repair programs differed in the monitoring frequency that could be implemented. As Tables 2-2 and 2-3 show, all of the monitoring programs would result in net credits because the value of recovered product resulting from implementation of each program is greater than the cost of each program. The largest emission reduction is associated with the monthly program. The incremental cost for a monthly program compared to a quarterly program is about $48,000/yr for existing valves and results in an incremental benzene emission reduction of about 400 Mg/yr; this represents an incremental cost effectiveness of about $120/Mg of benzene. Because EPA considers the incremental cost effectiveness associated with the monthly program to be reasonable, EPA selected a monthly leak detection and repair program as BAT for valves.

Pumps. The costs and emission reductions associated with the control of pumps were determined for three leak detection and repair programs and the use of dual mechanical seal systems. The incremental cost associated with the use of dual mechanical seal systems (compared to the monthly program) on existing pumps is about $3.3 million/yr and results in an incremental emission reduction of about 220 Mg/yr of benzene; this represents an incremental cost effectiveness of $15,000/Mg. Furthermore, the use of dual mechanical seal systems reduces an incremental 380 Mg/yr of total emissions (including benzene and other VOC). Because the incremental cost effectiveness ($15,000/Mg of benzene) is relatively high and because the additional emission reduction of VOC does not add enough weight to convince EPA that the costs are reasonable, EPA decided not to require the use of dual mechanical seal systems.

Next, EPA considered leak detection and repair programs for pumps. Monthly and quarterly leak detection and repair programs both result in net annual savings. The annual program results in a cost of about $250,000/yr for a benzene emission reduction of about 290 Mg/yr; this represents a cost effectiveness of about $870/Mg of benzene. EPA decided not to select an annual program as BAT because it results in higher costs and lower emission reductions in comparison to either a monthly or a quarterly program. The monthly program achieves a higher degree of control than the quarterly program at a slightly lower credit. The monthly program (compared to the quarterly program) results in a savings and an incremental emission reduction of about 180 Mg/yr of benzene; this represents an incremental cost effectiveness of essentially zero for existing pumps in benzene service. Because EPA considers the incremental cost effectiveness associated with monthly monitoring of pumps reasonable, monthly leak detection and repair was selected as BAT for pumps.

Compressors. One control technique is considered viable for compressors in benzene service--the installation of equipment such as control of the barrier fluid system. The installation of control equipment results in an emission reduction of about 3.5 Mg/yr per compressor at a savings in cost for each compressor. The control technique results in a savings because the value of product retained by controlling the barrier fluid system exceeds the cost of the control equipment. Since this cost is reasonable, control equipment was selected as BAT for compressors.

For existing compressors, EPA proposed a monthly leak detection and repair program. At proposal, EPA selected, as the basis of the standard for existing pumps and compressors, a monthly leak detection and repair program because some existing pumps could not be reasonably retrofitted with dual mechanical seal systems and because the cost of retrofitting compressors and replacing pumps (in comparison to the cost of a leak detection and repair program) was considered exorbitant in light of the resulting incremental emission reductions. Since proposal, EPA has concluded that the effectiveness of a leak detection and repair program for compressors in benzene service would be zero. Also, as requested by commenters, EPA has analyzed compressors separately from pumps. This analysis yields the cost and emission reduction estimates above. EPA has thus concluded that control equipment is reasonable for existing compressors and, therefore, selected it as BAT for existing compressors as well as new compressors.

Pressure relief devices. The annualized costs and emission reductions associated with monthly and quarterly leak detection and repair programs and with the use of control equipment (rupture disks and flares) were determined for pressure relief devices in gas service. As Tables 2-2 and 2-3 show, both the quarterly and monthly leak detection and repair programs are less expensive than installation of equipment controls, but they result in lower emission reductions. These programs result in an incremental cost effectiveness of about $300/Mg of benzene for the monthly program (compared to the quarterly program) and a credit for the quarterly program. Equipment controls would result (compared to a monthly program) in incremental emission reductions of about 30 percent and incremental costs of $1,500/Mg of benzene and $1,700/Mg of benzene ($940/Mg of total emissions and $1,100/Mg of total emissions) for new and existing equipment, respectively, compared to a monthly leak detection and repair program. However, for new pressure relief devices, the incremental cost effectiveness of comparing equipment controls with monthly monitoring could range from about $1,200/Mg of benzene or $760/Mg of total emissions (for rupture disk/block valve systems and venting to a flare) to about $3,000/Mg of benzene or $1,900/Mg of total emissions (for rupture disk/3-way valve systems). And for existing pressure relief devices, the incremental cost effectiveness could range from about $1,300/Mg of benzene or $820/Mg of total emissions for flare systems to about $3,800/Mg of benzene of $2,400/Mg of total emissions for rupture disk/3-way valve systems. Because the overall incremental cost effectiveness of equipment controls ($1,500/Mg of benzene or $940/Mg of total emissions for new equipment and $1,700/Mg of benzene or $1,100/Mg of total emissions for existing equipment) and average costs are considered reasonable and because equipment controls provide a significant incremental emission reduction, they were selected as BAT for pressure relief devices.

Open-ended lines, sampling connection systems, and product accumulator vessels. EPA considered caps or closures as the control technique for the standard for open-ended lines. Costs of $430/Mg and $470/Mg of benzene are reasonable for controlling equipment leaks of benzene from new and existing open-ended lines, respectively. EPA selected caps or closures as BAT for open-ended lines.

EPA considered closed-purge sampling as the control technique for the standard for sampling systems. Costs of $880/Mg and $900/Mg of benzene are reasonable for controlling equipment leaks of benzene from new and existing sampling systems, respectively. EPA selected closed-purge sampling as BAT for sampling systems.

EPA considered closed-vent systems connected to a control device as the control technique for the final standard for product accumulator vessels. For existing units in benzene service, the installation of closed-vent systems connected to a control device will result in a nationwide net annual cost of $10,300 and an annual emission reduction of about 100 Mg of benzene; this represents a cost effectiveness of about $100/Mg. Since the cost associated with this control technique is reasonable, EPA selected closed-vent systems as BAT for product accumulator vessels.

Economic impact considerations of BAT. As mentioned above, once BAT was identified for each type of equipment covered by the standard, EPA analyzed the economic impact of the initial set of BAT control techniques. As a result and as explained in the next section of this preamble, EPA concluded that the control techniques initially selected as BAT have reasonable economic impacts. In addition, EPA has also concluded that other impacts, environmental and energy, associated with these control techniques are reasonable. Thus, they were selected as BAT for equipment in benzene service.

Selection of the final standards. After selecting certain control techniques as BAT (those identified above), EPA evaluated the estimated health risks remaining after application of BAT to determine if they are unreasonable in view of health risk reductions and cost (economic) impacts that would result if a more stringent level of control were applied. Because the most stringent, viable control technique for each type of equipment covered by the standard is already selected for all types of equipment except for valves and pumps, EPA identified a more stringent level of control by reviewing the control techniques for valves and pumps. The more stringent level of control used for this analysis includes the use of dual mechanical seal systems on pumps in addition to the requirements selected as BAT. This control technique was selected for analysis because it adds the next most cost-beneficial control technique. Thus, if EPA decided not to require this control technique in addition to those control techniques selected as BAT, then EPA would not require less cost-beneficial control techniques, such as sealed bellows valves.

Health and cost impacts were first examined for existing equipment covered by the standard to determine whether a more stringent level of control should be required. Requiring a more stringent level of control instead of BAT would reduce estimated leukemia incidence within 20 kilometers of the equipment covered by the standard from about 0.14 cases per year to about 0.13 cases per year for existing equipment. It would reduce the estimated maximum lifetime risk at the point of maximum exposure from about 4.5×10^{-4} to about 4.2×10^{-4}. Due to the assumptions used in calculating the health numbers, there is uncertainty associated with the numbers presented here. The uncertainties associated with these numbers are explained in Section 2.1.2 entitled "Need for the Standard." Requiring the more stringent level of control rather than BAT would increase capital cost from $5.5 million to $19.5 million and would increase net annualized costs from $400 thousand to a cost of $3.7 million for existing equipment. Because of the relatively small health benefits to be gained with the additional costs of requiring the more stringent level of control instead of BAT for existing equipment, EPA considers the risks remaining after application of BAT to existing equipment not to be unreasonable. For this reason, EPA judged the level of control selected as BAT to provide an ample margin of safety and decided not to require a more stringent level of control than BAT for existing equipment.

Health and cost impacts were next examined for new equipment covered by the standard to determine whether a more stringent control level should be required. As with existing equipment, EPA considered the use of dual mechanical seal systems on pumps as the more stringent control level that is next most cost beneficial. Thus, if EPA decides not to require the use of these seals, then EPA would not require less cost beneficial control technologies, such as sealed bellows valves. Requiring the more stringent level of control--the use of dual mechanical seals on pumps in addition to BAT--could reduce estimated leukemia incidence within 20 kilometers of the equipment covered by the standard from about 0.038 cases per year to about 0.035 cases per year for new equipment.

It would reduce the estimated maximum lifetime risk at the point of maximum exposure from about 4.5×10^{-4} to about 4.2×10^{-4}. The uncertainties associated with the numbers are explained in Section 2.1.2. Requiring the more stringent level of control rather than BAT would increase capital costs from $1.4 million to $5.1 million and net annualized costs of $100 thousand to $900 thousand for new equipment. Because of the relatively small health benefits to be gained with the additional costs of requiring the more stringent level of control instead of BAT for new equipment, EPA considers the risks remaining after application of BAT to new equipment not to be unreasonable. For this reason, EPA judged the level of control selected as BAT to provide an ample margin of safety and decided not to require a more stringent level of control than BAT for new equipment.

2.4 CONTROL TECHNOLOGY

2.4.1 Equipment Specifications

2.4.1.1 Flare Systems. Comment: Many commenters objected to EPA's exclusion of flare systems as a control device (IV-D-13; IV-D-18; IV-D-20; IV-D-21; IV-D-22; IV-D-24; IV-D-27; IV-F-1). The comments addressed the following issues: (1) flare efficiencies, (2) on-going EPA flare study, (3) safety aspects of flares, and (4) cost effectiveness of flares.

Response: At proposal, flares were not considered an acceptable control technique for elimination of fugitive emissions of benzene. The results of studies that were available were considered inapplicable to the streams to be controlled. In some studies the flare design was not representative of flares in the industry. In others the analytical method was questionable. At that time no approved method for measuring flare efficiency (evaluating flare performance) was available.

Theoretical calculations indicated that flare efficiency could be as low as 60 percent for destruction of benzene in low-flow, intermittent streams sent to a large flare. This efficiency was cited in several background documents (Ethylbenzene/Styrene, Benzene Fugitive, SOCMI Fugitive VOC) and served as a primary consideration in not allowing the general use of flares. However, this theoretical computation was based on assumptions that may not be applicable to the design situation under study.

The use of flares, therefore, was reconsidered for the benzene fugitive emission standard. Commenters pointed out potential operational difficulties associated with the use of incinerators that could be avoided with the use of flares. A major difficulty seen was in designing systems for the low-volume and intermittent flow to the control device. In addition, consideration was given to the extensive use of flares by industry to handle emergency releases. Since flares are currently in widespread use in the chemical and petroleum refining industries, they represent a large investment in control by the industries.

The following presents a review of flares and operating conditions used in five studies of flare combustion efficiency. Each study can be found in complete form in the docket.

Palmer (IV-J-3) experimented with a 1/2-inch ID flare head, the tip of which was located 4 feet from the ground. Ethylene was flared at 50 to 250 ft/sec at the exit, (0.4×10^6 to 2.1×10^6 Btu/hr). Helium was added to the ethylene as a tracer at 1 to 3 volume percent and the effect of steam injection was investigated in some experiments. Destruction efficiency (the percent ethylene converted to some other compound) was 97.8 percent.

Siegel (II-D-92) made the first comprehensive study of a commercial flare system. He studied burning of refinery gas on a commercial flare head manufactured by Flaregas Company. The flare gases used consisted primarily of hydrogen (45.4 to 69.3 percent by volume) and light paraffins (methane to butane). Traces of H_2S were also present in some runs. The flare was operated from 0.03 to 2.9 megagrams of fuel/hr (287 to 6,393 lb/hr), and the maximum heat release rate was approximately 235×10^6 Btu/hr. Combustion efficiencies (the percent VOC converted to CO_2) averaged over 99 percent.

Lee and Whipple (IV-J-5) studied a bench-scale propane flare. The flare head was 2 inches in diameter with one 13/16-inch center hole surrounded by two rings of 16 1/8-inch holes, and two rings of 16 3/16-inch holes. This configuration had an open area of 57.1 percent. The velocity through the head was approximately

3 ft/sec and the heating rate was 0.3 M Btu/hr. The effects of steam and crosswind were not investigated in this study. Destruction efficiencies were 99.9 percent or greater.

Howes, et al. (IV-A-20) studied two commercial flare heads at John Zink's flare test facility. The primary purpose of this test (which was sponsored by the EPA) was to develop a flare testing procedure. The commercial flare heads were an LH air-assisted head and an LRGO (Linear Relief Gas Oxidizer) head manufactured by John Zink Company. The LH flare burned 2,300 lb/hr of commercial propane. The exit gas velocity based on the pipe diameter was 27 ft/sec and the firing rate was 44 x 10^6 Btu/hr. The LRGO flare consisted of three burner heads 3 feet apart. The three burners combined fired 4,200 lbs/hr of natural gas. This corresponds to a firing rate of 83.7 x 10^6 Btu/hr. Steam was not used for either flare, but the LH flare head was in some trials assisted by a force draft fan. Combustion efficiencies for both flares during normal operation were greater than 99 percent.

An excellent detailed review of all four studies was done by Joseph, et al. (IV-A-21), and a summary of the studies is given in Table 2-4. A fifth study by McDaniel, et al. (IV-A-28) determined the influence on flare performance of mixing, Btu content, and gas flow velocity. A steam-assisted flare was tested at the John Zink facility using the procedures developed by Howes. The test was sponsored by the Chemical Manufacturers Association (CMA) with the cooperation and support of the EPA. All of the tests were with an 80 percent propylene, 20 percent propane mixture diluted as required with nitrogen to give different Btu/scf values. This was the first work that determined flare efficiencies at a variety of nonideal conditions where lower efficiencies had been predicted. All previous tests were of flares burning gases that were very easily combustible and did not tend to soot. This was also the first test that used the sampling and chemical analysis methods developed for the EPA by Howes.

The steam-assisted flare was tested with exit flow velocities ranging from 0.02 to 60 ft/sec, with Btu contents from 200 to 2,183 Btu/scf

Table 2-4. FLARE EMISSION STUDIES COMPLETED AS OF OCTOBER 1982

Investigator	Sponsor	Docket No.	Flare Tip Design	Flared Gas	Throughput 10^6 Btu/hr	Flare Efficiency %
Palmer (1972)	E.I. du Pont	IV-J-3	0.5" dia.	Ethylene	0.4 - 2.1	97.8 - >99
Lee & Whipple (1981)	Union Carbide	IV-J-5	Discrete Holes in 2" dia. cap.	Propane	0.3	>99.99
Siegel (1980)	Ph.D. Dissertation University of Karlsruhe	II-D-92	Commercial Design (27.6" dia. steam)	~50% H_2 plus light hydrocarbons	49 - 178	>99
Howes et al. (1981)	EPA	IV-A-20	Commercial Design (6" dia. air assist)	Propane	44	>99
			Commerical Design H.P. (3 tips @ 4"dia.)	Natural Gas	28 (per tip)	>99
McDaniel et al. (1982)	CMA-EPA	IV-A-28	Commercial Design	Propylene	0.01 - 57	83 - 99.9

and with steam to gas (weight) ratios varying from 0 (no steam) to 6.8611. Steam-assisted and air-assisted flares were tested with fuel gas heat contents as low as 300 Btu/scf. Flares without assist were tested down to 200 Btu/scf. This efficiency was also found to be achievable for air-assisted flares combusting gases with heat contents over 300 Btu/scf and with exit gas velocities below a maximum value (depending upon the heat content of the gas stream). All of these tests, except for those with very high steam to gas ratios, showed combustion efficiencies of over 98 percent. Flares with high steam to gas ratios (about 10 times more steam than that required for smokeless operation) had lower efficiencies (69 to 82 percent) when combusting 2,183 Btu/scf gas.

After consideration of the results of these five tests, EPA has concluded that 98 percent combustion efficiency can be achieved by steam-assisted flares with exit flow velocities less than 60 ft/sec combusting gases with heat contents over 300 Btu/scf and by flares operated without assist with exit flow velocities less than 60 ft/sec gases with heat contents over 200 Btu/scf. Flares are not normally operated at the very high steam to gas ratios that resulted in low efficiency in some tests because steam is expensive and operators make every effort to keep steam consumption low. Flares with high steam rates are also noisy and may be a neighborhood nuisance.

EPA has a program under way to determine more exactly the efficiencies of flares used in the petroleum refining and chemical industries, and a flare test facility has been constructed. The combustion efficiency of four flares (1 1/2 inches to 12 inches ID) will be determined, and the effect on efficiency of flare operating parameters, weather factors, and fuel composition will be established. The efficiency of larger flares will be estimated by scaling.

According to the current knowledge of flare design, the best available flare design (i.e., the state-of-the-art flare design) is the smokeless flare. The smokeless flare introduces air into the flame by injection of steam or air. This injection of steam or air increases the mixing of the flared compounds with the flame zone, thereby increasing the destruction of the compounds. Smoking flares are environmentally less desirable because they emit particulate. It is difficult, however, to maintain smokeless operation unless the off-gas flow to the flare is constant. When the off-gas flow rate increases, there is a short period of time before the smoke sensor responds and additional steam (or air) reaches the flare tip. During this period, the flare smokes. Smoking may also occur during large emergency discharges because insufficient steam (or air) is available in the plant to make these infrequent discharges nonsmoking. A number of engineering practices currently used in industry help to achieve continuous smokeless operation. These include staged elevated flares, dual flare tips (small tip for low-flow, large tip for emergency releases), and continuous flare gas recovery systems. These systems are further discussed later in this section.

Taking all of these factors into consideration, EPA decided to allow use of smokeless flares operated with a flame present to control fugitive emissions of benzene. In order to ensure that the smokeless flare operates with a flame present, the flare's pilot light is to be monitored with an appropriate heat sensor, such as a thermocouple. To ensure smokeless operation, visible emissions from a flare would be limited to less than 5 minutes in any 2-hour period. In addition, steam-assisted flares would have to be operated with exit velocities less than 60 ft/sec combusting gases with heat contents greater than 300 Btu/scf. Flares operated without assist would have to be operated with exit velocities less than 60 ft/sec combustion gases with heat contents greater than 200 Btu/scf. Air-assisted flares would have to be operated with exit velocities below a maximum value, depending upon the gas heat content which must be greater than 300 Btu/scf. Flares operated within these requirements are considered as acceptable alternatives to enclosed combustion devices (incinerators, boilers, process heaters) and vapor recovery systems, such as carbon adsorbers and condensation units. They may be applied to control of emissions from pump seals (or degassing reservoirs), compressor seals (or degassing reservoirs), and pressure relief devices.

As mentioned above, EPA has a program under way to determine the effectiveness of flares not studied to date. As this data and information are collected and evaluated, EPA plans to update the requirements for flares. It is not expected that the requirements would become more restrictive. Until the requirements are updated, plant owners and operators are allowed to determine whether other flare systems are equivalent to the systems required in the standard.

Comment: One commenter expressed concern that excluding flares as an enclosed combustion device would cause potentially unsafe conditions when venting emissions from product accumulator vessels. The commenter detailed safety problems associated with venting receivers to fired heaters, vapor recovery systems, and incinerators. The commenter recommended that benzene-containing receiver vessels continue to be vented to properly designed flare systems unless there is evidence that benzene destruction is insufficient (IV-D-22).

Response: As previously indicated, EPA has determined that smokeless flares designed for the expected flowrates will be accepted as a control device for benzene fugitive emissions, including emissions from product accumulator vessels.

Comment: Three commenters stated that nonflare systems are not as cost effective as flare systems (IV-D-18; IV-D-22; IV-F-1), and another commenter noted that flare systems can achieve or approach the same degree of emission reduction as enclosed combustion devices or vapor recovery systems at significantly lower costs (IV-F-1). One of the commenters stated that using an incinerator to control intermittent vents would cost about $3 million (including piping) (IV-D-18).

Response: As previously indicated, EPA has determined that smokeless flares designed for the expected flowrates will be accepted as a control device for benzene fugitive emissions.

2.4.1.2 Pump and Compressor Seals. Several commenters questioned the requirements on pump and compressor seals. Several commenters noted the inflexibility of the dual seal requirements. Other comments were received about the barrier fluid systems, costs of dual seals, and sealless pumps and compressors.

Comment: Two commenters felt that the requirement to use dual mechanical seals on new pumps is inflexible or overly restrictive (IV-D-24; IV-D-13). One commenter, who submitted two sets of comments, felt similarly about new compressors (IV-D-27; IV-D-13). The commenter felt that the requirement for specific types of mechanical seals on compressors is inflexible and cannot be applied in all cases.

One commenter noted that in one of its refineries dual seals leak more than single seal pumps. The commenter recommended that the dual mechanical seal requirement be deleted and that a properly installed benzene sensor and alarm system be used to detect pump seal leaks. The commenter has found that area-type benzene monitoring systems are very reliable in actual plant use. The commenter further noted that the combination of single mechanical seal pumps and a benzene sensor-alarm system would cost less than dual seal systems and would be more effective in reducing emissions (IV-D-20).

Response: Since proposal, EPA decided to allow the less stringent monthly leak detection and repair program as the standard for new and existing pumps (See Section 2.3). Therefore, the final regulation for new and existing pumps requires a monthly leak detection and repair program using a 10,000 ppm leak definition, as determined by the leak detection method specified in §61.245. Leaking pumps must be repaired as soon as practicable but within 15 days.

The standard also provides alternatives to the work practice standard. The two choices are as follows: (1) installation of a properly designed mechanical seal system with an associated barrier fluid system as specified in §61.242-2(d), and (2) installation of a closed-vent system as described in §61.242-2(f). The standard for pumps gives the owner or operator the flexibility to choose the best means of controlling emissions from pumps at his or her process unit. In any given process unit, however, an owner or operator may select to use equipment for some pumps and apply the work practice standard to the remaining pumps.

One of the commenters appears to be questioning the effectiveness of dual versus single seal systems on pumps. Contrary to the commenter's experience at one refinery, EPA studies have found that dual seals do not leak more often than single seals. Also, EPA has found that dual mechanical seals may not be any more effective than single seals unless the barrier fluid used to control VOC emissions is a heavy liquid or, in the control of benzene emissions, unless the barrier fluid is not benzene. For example, if a VOC or benzene-containing barrier fluid is used on a dual seal, the outer seal would function similar to a single seal. However, pumps equipped with dual seals would have less emissions than pumps with single seals if the appropriate barrier fluid is used. As stated previously in this response, the dual seal requirement on pumps has been deleted but has been retained as an alternative standard. If the owner or operator chooses to install dual mechanical seals instead of implementing a leak detection and repair program, a barrier fluid system using a nonbenzene and non VOC barrier fluid and equipped with a sensor must be used.

The use of single seals with a sensor-alarm system may be less expensive than a dual seal system, but the effectiveness of this approach depends on the specific sensor-alarm system. Therefore, it is not practicable to define general standards to cover this approach. However, an owner or operator can request equivalency for such an approach.

As discussed in Section 2.3, the effectiveness of a leak detection and repair program for compressors essentially would be zero because compressors generally are not spared and, therefore, repair would be delayed until the next turnaround. Because EPA judges that equipment controls for compressors are available and the cost is reasonable (see Section 2.3), equipment was selected as BAT for existing and new equipment.

Comment: One commenter noted that it was unclear if tandem seals (dual seals where the barrier fluid is not at a greater pressure than the stuffing box) are allowed. The commenter recommended that the definition of tandem seals be clarified and that tandem seals should be allowed as a control device. The commenter believed that tandem seals along with the weekly visual checks and 5-day/15-day repair requirements would eliminate the need to degas and incinerate since sources will not leak for any extended period of time (IV-D-30).

Response: As stated in the preamble of the proposed benzene fugitive emissions standard (46 FR 1178, January 5, 1981, Column 3), the term "dual mechanical seal systems" includes both double and tandem seal designs. A printing error excluded the complete definition of a tandem mechanical seal system in the preamble. As defined in a memorandum of printing errors in the FEDERAL REGISTER publication

(IV-B-3), tandem mechanical seal systems have two seals in a front-to-back arrangement. The preamble describes the remainder of the term as having a barrier fluid with pressure maintained lower than the pump stuffing box pressure. Under the proposed standard, either the tandem or double (back-to-back) seal arrangement would have been allowed for new pumps in benzene service.

As stated in the preceding response, however, the standard has been revised since proposal. The promulgated standard allows the plant owner or operator to select the use of a work practice standard for new and existing pumps in benzene service (monthly leak detection and repair program with a leak definition of 10,000 ppmv) instead of the equipment standard. If the owner or operator selects the equipment (dual seal) standard for new pumps, then he would not need to include his pumps in a monthly leak detection and repair program. When dual seal systems are used, EPA believes that equivalent emissions reduction can be achieved if leakage of process fluid into the barrier fluid is controlled by either (1) degassing and venting emissions to a control device or (2) continuously replacing the fluid with fresh barrier fluid and disposing of the contaminated barrier fluid.

Comment: One commenter stated that requiring a seal sensor to monitor catastrophic seal failure and visual inspections for liquid dripping from the seal is redundant and recommended that the operator be permitted to do one or the other (IV-D-24).

Response: As a requirement of Section 112(e) of the Clean Air Act, provisions must be made to ensure the proper operation and maintenance of control systems required by equipment standards. If an owner or operator chooses to install equipment rather than comply with a work practice standard, outer seal failure will be noted through periodic visual inspections (i.e., weekly visual inspections). However, some form of indicator is needed to indicate catastrophic failure of an inner seal of a dual seal arrangement. These practices (seal sensor and weekly visual inspections) are not redundant, since they are both necessary for ensuring proper maintenance of the dual seal system.

Comment: Two commenters questioned the barrier fluid system requirement. One commenter referred to comments made on the SOCMI VOC fugitives NSPS (IV-D-21). This comment and EPA's response are presented in the SOCMI VOC Fugitives NSPS BID for the promulgated standard (EPA-450/3-80-033b). Another commenter noted that there is no definition of barrier fluid and recommended that the vapor pressure of the barrier fluid be less than one atmosphere at seal operating temperature. The commenter believed that if a barrier fluid is simply any benzene"free" fluid, the system may not meet the proposed standard. The commenter stated that a specification of "benzene-free" as less-than-or-equal-to 10 percent benzene by weight provides no clue as to an acceptable fluid vapor pressure. The commenter also stated that since the barrier fluid, whether process fluid or contained fluid, will be emitted by the seal as it cools the seal faces, the fluid's heat capacity, enthalpy, and vapor pressure at seal operating temperatures are key issues (IV-D-24). The commenter further believed that barrier fluid systems operating at a pressure above the stuffing box pressure may lead to unsafe conditions and that leakage into some process fluids might result in fires or explosions (IV-D-24).

Response: As described in previous responses in this section, the standard for new pumps in benzene service has been revised since proposal. The final standard, in addition to allowing the equipment alternatives previously specified, requires the use of a work practice standard for both new and existing pumps. The use of the equipment alternatives results in better than equivalent emission reduction; therefore, EPA is allowing equipment controls as an alternative standard for pumps. In any given process unit, an owner or operator may choose to use equipment for some pumps and apply the work practice standard to the remaining pumps. If he chooses to use the equipment on a pump, he will not need to include that pump in a monthly leak detection and repair program. As discussed in a previous response in this section, EPA selected equipment controls as BAT for both new and existing compressors.

A nonbenzene barrier fluid must be used with mechanical seal systems for compressors and with dual seal systems for control of benzene emissions from pumps if an owner or operator chooses to install equipment in lieu of leak detection and repair of pumps. If a benzene-containing barrier fluid were used instead, the seal would not be effective in terms of sealing benzene from atmosphere. Leakage through and failure of the outer seal would result in benzene emissions.

For pumps and compressors covered by standards of performance (Section 111), EPA decided also to specify a vapor pressure for VOC barrier fluids used with seal systems for pumps or compressors. Because these systems could leak VOC if not required to use a heavy liquid barrier fluid and because these systems would otherwise be covered by petroleum refinery and synthetic organic chemical manufacturing industry standards, EPA decided to limit barrier fluids to make the dual seal system effective. This only applies where the barrier fluids would be limited by standards of performance under Section 111. In summary, an owner or operator can select any barrier fluid that does not contain greater than 10 percent benzene and is a heavy liquid VOC or a nonVOC.

One of the commenters expressed concern about the safety of barrier fluid pressures above the pump stuffing box pressure. This pressure allowance is common practice, but it is not recommended or required in all cases. The barrier fluid requirement is flexible and allows the owner or operator to consider safety, design, and operating conditions of specific processes.

Comment: Two commenters remarked about sealless pumps and compressors. One of the commenters questioned the method for specifying the acceptability of enclosed pumps and asked how to measure the concentration of an enclosed pump if there is no shaft that penetrates the pump housing (IV-D-24).

The other commenter noted that sealless pumps, which are extremely effective, are not required, according to the proposed standard, because they can be used at only a limited number of emission points. The commenter added that sealless compressors are not required because they are said not to be widely available. Therefore, the commenter recommended that sealless pumps and compressors be required where they can be used. The commenter added that production and availability of sealless compressors would increase if they were required for future plants (IV-D-31).

Response: Since leakless equipment has limited applications in the chemical and petroleum refining industries, leakless equipment is not required by the regulation. EPA cannot specify where leakless equipment can and cannot be used at this time. However, leakless equipment is allowed as an alternative to the standards for pumps and compressors without a determination of alternative means of emission limitation. They are exempt from the routine monitoring requirements by setting a performance standard of no detectable emissions.

The provisions for leakless technology are presented in §61.242-2(e) for pumps. The provisions deal only with pumps whose shafts do not penetrate the pump housing, i.e., sealless and canned pumps. These pumps are excluded from leak detection and repair only if they are operated with no detectable emissions above background as measured by methods set forth in the regulation. Similar provisions are given in §61.242-3(i) for compressors and in §61.242-7(f) for valves. Leakless seal technology is not precluded by these provisions. Other types of leakless seal technology that may be developed could become an accepted control alternative if adequately demonstrated through the alternative means provisions of §61.244.

The no detectable emissions limit of 500 ppmv above background concentration that is required for enclosed pumps and compressors is based on the measurement method of Reference Method 21. The portable VOC analyzer is used to determine the local ambient VOC concentration in the vicinity of the source to be evaluated, and then a measurement is made at the surface of the potential leak interface. The potential leak interfaces include bolted flanges and other assemblages. If a concentration change of less than 5 percent of the leak definition is observed, then a "no detectable emissions" condition exists. The definition of 5 percent of the leak definition was selected based on the sensitivity of the instrument, which reads ± 5 percent of the meter scale. "No detectable emissions" would exist when the observed concentration change between local ambient and leak interface surface measurements is less than 500 ppmv.

Comment: Two commenters remarked about the costs associated with dual seal systems. One commenter reported that one of the refineries contacted in the area estimated a minimum cost of $200,000 for installation of secondary seals with an estimated $35,000 annual maintenance and monitoring cost (IV-D-10). One commenter evaluated the use of dual mechanical seals with a barrier fluid and controlled degassing vents. The commenter concluded that safe installation of this type of system is very expensive and would only control minor amounts of benzene (IV-D-29).

Response: Since proposal, a monthly leak detection and repair program has been selected for control of benzene fugitive emissions from new and existing pumps (see Section 2.3). For new and existing compressors, EPA has selected equipment control. EPA has estimated costs of installing safe systems and has concluded that they are reasonable.

2.4.1.3 Sampling Systems. Four commenters submitted the following comments on the sampling system requirements:

Comment: One commenter recommended that the last five words of paragraph (2), Sec. 62.112(c) of the proposed standard, "without benzene emissions to atmosphere," should be changed to, "with minimal emissions to atmosphere." The commenter noted that designing sampling systems with zero benzene emissions would require using a benzene-free purge. The commenter recommended that only specially designed sampling valves should be required (IV-D-20). One commenter recommended that other sampling systems besides a purge system be allowed, for example, venting to a control device with 95 percent recapture (IV-D-21). Another commenter stated that sampling systems are not state-of-the-art for worker protection. The commenter also recommended that a definition of in-situ sampling systems be added to the standard (IV-D-24).

Response: In the BID for the proposed standard, it was estimated that closed-loop sampling systems are almost 100 percent effective in eliminating sampling purge emissions. As noted in the preamble of the proposed standard (46 FR 1180, January 5, 1981), however, no available data indicate that application of any control technique would be able to comply with a "no detectable emissions" standard (500 ppmv or less VOC concentration above background). Some benzene could be emitted during sample transfer to a closed collection device.

The intent of the standard is to eliminate sample line purging to atmosphere, ground, or sewer drain. A "zero" (no detectable) emissions limit is not practicable as noted by the establishment of an equipment standard instead of an emissions limit because sampling systems can have detectable emissions. Reference Method 21 would not be practicable for determining emissions from these systems.

EPA recognizes that closed-loop sampling systems have limitations with respect to low-pressure processes or tankage and, in some instances, safety requirements. The regulation, therefore, does not specify a "closed-loop sampling system," but it does require a "closed-purge system." This will allow any system that collects all benzene purged during sampling and recycles or destroys the collected benzene. Closed-loop sampling systems are used in the BID for the proposed standard to evaluate the cost of controlling fugitive emissions from sampling systems (closed-loop sampling systems are generally the most costly system to implement a closed purged system).

The intent for sampling systems has been clarified in the final standard with the changes presented in response to other comments. By elaborating on the requirements for "closed-purge systems" and "in-situ" sampling systems, the proper equipment design criteria for sampling systems have been better described:

"Closed-purge system" means the equipment comprising a closed-loop sampling system or any system that collects benzene purged in the sampling process and either recycles or disposes of benzene.

"In-situ sampling systems" are non-extractive or in-line sampling systems that involve measurement or sampling of process stream conditions without extraction of the sample from the process stream, resulting in no purged emissions of benzene.

In addition to closed-purge sampling, EPA has considered since proposal allowing a closed-vent vacuum system connected to a control device. Closed-vent vacuum systems connected to a control device collect the sample purge and then transport the sample purge to a control device. If these systems are not open to atmosphere, then their reduction in emissions of benzene would be equivalent to collecting the purge in a collection system that is not open to atmosphere. Based on these considerations, EPA has decided to allow closed-vent vacuum systems connected to control devices.

Comment: One commenter stated that there were the following problems in controlling emissions of benzene in accordance with the proposed regulations:

(1) Attempts to perform closed-loop sampling of nitration batches at one plant were unsuccessful.

(2) One plant anticipated problems with closed-loop sampling of raw material deliveries and reactor content measurements (IV-D-29).

Response: As stated in the previous response, EPA specifies in the proposed and promulgated regulations "closed-purge systems" as the control equipment for sampling systems, not "closed-loop sampling systems." Requiring "closed-purge systems" allows any system that collects all benzene purged during sampling and recycles or destroys the collected benzene. An example system is that of the Fetterolf-"Ram-seal" presented in Docket A-79-27-II-D-56.

2.4.1.4 Continuous Benzene Emissions Control. Comment: One commenter expressed concern for the requirement that all control systems be operated 100 percent of the time when benzene emissions may occur. The commenter was concerned that the provision does not allow for expected or unexpected maintenance or repair of the control system. The commenter recommended that a bypass of emissions be allowed where the control systems must be taken out of service for maintenance or an emergency only where the next emissions that will be bypassed would not exceed the excess emissions that would result from a shutdown and start-up of the process unit (IV-D-21).

Response: The standard requires that control devices be operated when emissions of benzene are vented to them. This means that closed-vent systems transporting the benzene emissions to control devices can not be vented uncontrolled to atmosphere. For larger emissions, current industry practices do not allow uncontrolled venting of emissions from closed-vent systems. Thus, alternative control devices will be available to control these emissions. For smaller emissions, such as those from dual mechanical seal systems, the closed-vent system can be isolated from the control device long enough to repair or maintain the control device.

2.4.1.5 Open-ended Lines. Comment: One commenter stated that EPA did not recognize block-and-bleed operations in reference to open-ended lines (IV-D-21).

Response: Provisions were made in the proposed standard for block-and-bleed operations. Sections 61.112(d)(6) and (7) of the proposed standard required:

> "(6) Each open-ended valve shall be equipped with a cap, blind, plug, or a closed second valve that is attached to seal the open end at all times except during operations requiring flow through the open-ended valve.
>
> (7) Each open-ended valve equipped with a second valve, as required in Section 61.112(d)(6) shall be operated such that the open-ended valve is completely closed before the second valve is closed."

Where a block-and-bleed system is being used, the bleed valve (second valve) must "seal the open end at all times except during operations requiring process fluid flow through the open-ended line." The bleed valve, therefore, can remain open when venting the space between the two block valves. Bleed valves are exempt when they are operational, but require a cap when not in use.

2.4.1.6 Enclosed Combustion Devices. Comment: Two commenters questioned the required design conditions for enclosed combustion devices. One commenter noted that a temperature requirement with a residence time is not specific enough to guarantee 95 percent benzene destruction. The commenter recommended that an offgas oxygen level should be specified if pyrolysis operating conditions are inadequate. The commenter recommended that the level of destruction should be specified and that the designer/operator should specify the operating conditions. The commenter proposed the criterion of, "equipped with a barrier fluid degassing reservoir that is connected by a closed-vent system to a combustion device or to a vapor recovery system designed for a minimum of 95 percent destruction or capture of benzene input to the combustion device or vapor recovery system, respectively." The commenter added that this criterion could also be applied to Section 61.112(a)(7) of the proposed standard (IV-D-24).

The commenter also expressed concern that closed-vent systems and enclosed combustion devices introduce fire and explosion hazards into many workplaces (IV-D-24). The other commenter noted that, in reference to product accumulator vessel vents being connected to a combustion device, a minimum temperature of 760 °C (1,400 °F) is probably excessive in achieving 95 percent destruction of benzene vapors (IV-D-20).

Response: Temperature and residence time are critical parameters influencing benzene destruction efficiency. They remain as one criterion that can be used to demonstrate compliance with the standard; however, EPA has made it clear in the final regulation that other control system design criteria can be used to demonstrate compliance with the standard. In addition to thermal incinerators, other control devices with high efficiencies are available and operate under less severe conditions. For example, catalytic incinerators operate with high control efficiency under much reduced temperature-residence time requirements. Also, boilers or process heaters combust benzene emissions from low flow sources, such as accumulator vessel vents and seal oil degassing system vents. For some sources, flares will be selected as the control devices. In yet other circumstances, vapor recovery devices may be preferable to enclosed combustion. Well-designed, existing enclosed combustion devices and vapor recovery systems can achieve the emission reduction efficiencies of better than 95 percent. Thus, EPA selected a benzene reduction efficiency of 95 percent for enclosed combustion devices.

2.4.1.7 Pressure Relief Devices. Comment: Two commenters questioned the requirement for controlling benzene emissions from pressure relief devices. One commenter questioned the practical use of rupture disks with block valves as an effective means for reducing emissions to less than 200 ppm. The commenter added that existing safety/relief valves converted to special discs having o-ring seals (in order to meet emission limits) could not be recommended for services above 400 °F. The commenter noted that a negligible degree of additional control would result especially since there are few relief valves compared to the number of control valves (IV-D-20). The other commenter stated that since the no detectable emissions level is above the OSHA STEL criterion of 25 ppm (i.e., 15-minute ceiling level based on the ability to monitor), a warning should be included in the standard noting that monitoring of emissions should be done in accordance with OSHA rules (IV-D-24).

Response: During normal operations rupture disks provide effective control of fugitive emissions from safety/relief valves. In order to determine whether the disk is properly sealing the system against leaks, a pressure gauge can be installed in the pocket between the disk and the safety/relief valve. The proposed standard, however, does not preclude the use of control techniques other than rupture disks. The proposed standard for no detectable emissions may be achieved by transporting emissions via a closed-vent system to a control device (i.e., flare system). In regard to the comment on the use of relief valves with o-ring seals, EPA does not have information indicating that these would result in less than 500 ppmv (no detectable emissions). If they do, then the owner or operator is responsible for understanding their limitations.

Although pressure relief devices represent a small fraction of the emission sources as indicated by one of the commenters, they contribute a relatively large proportion of the total volume of fugitive emissions. Pressure relief devices represent over 11 percent of the total uncontrolled fugitive emissions. The uncontrolled emission factor for pressure relief devices (3.9 kg/day) is 15 times greater than the emission factor for light liquid valves and 6 times greater than the uncontrolled factor for gas valves.

EPA is relying on the OSHA standards to protect occupational safety and health. The standard does not require plant operators to perform activities not otherwise performed by current industry practices. EPA expects owners or operators to adhere to occupational safety and health regulations in implementing the standard. However, it is not appropriate to note this in the standard and, therefore, it is not included.

2.4.1.8 Valves. Comment: One commenter suggested that diaphragm or bellows valves be required where they can be used despite the fact that their use is limited (VI-D-31).

Response: Diaphragm and bellows valves have limited applicability in the chemical and petroleum refining industries. Temperature or pressure constraints on the diaphragm elastomer or the susceptibility of bellows to corrosion restrict the use of these leakless valves. As explained in Section 2.3, the costs are considered unreasonably high.

2.4.1.9 Product Accumulator Vessels. Comment: One commenter stated that one plant indicated that controlling emissions from product accumulator vessels to "no detectable emissions" would require very great expense for very little control (IV-D-29).

Response: As discussed in the preamble to the proposed standard, the control technique of connecting existing and new product accumulator vessels to a control device with a closed vent system was evaluated during selection of the proposed standard. EPA selected this control technique as the basis for the proposed standard. However, as the commenter points out, the proposed standard required that accumulator vessels be operated at a state of emissions having a concentration less than 200 ppm above background using Method 21 (See proposed §61.115(b)), that is, having "no detectable emissions." This requirement did not mean that emissions must be eliminated completely, but rather the emissions must be vented to a control device as stated in proposed §61.112(e)(3). Method 21 was used to determine "no detectable emissions" to ensure the closed vent system does not leak.

Because this commenter did not clearly understand EPA's intent as expressed in the proposed standard, EPA has redrafted this requirement to make it clear that accumulator vessel vents must be vented to a control device. In the section on control devices and closed vent systems, Method 21 is still used to ensure the closed vent system does not leak. EPA also deleted the proposed §61.112(e)(2) because double coverage of ethylbenzene or styrene plants is no longr a concern.

Because the commenter questioned the costs of this requirement. EPA reviewed the costs of controlling accumulator vessel vents. In Appendix F to the BID for the proposed standard, EPA estimated the nationwide benzene emissions total would include 130 Mg/yr from accumulator vessels and the annualized cost would be about $11,000. The commenter did not question these estimates or provide a basis to evaluate these estimates further. In Appendix A, Table A-10 of the BID for the promulgated standard, EPA reevaluated the cost and effectiveness of controlling product accumulator vessels and estimated the cost effectiveness to be about $100/Mg. EPA considers such a cost effectiveness reasonable for BAT. Therefore, EPA did not change the substantive requirements for product accumulator vessels.

2.4.2 Leak Detection and Repair Requirements

Several commenters recommended changes in the proposed leak detection and repair requirements. Most of the comments referred to adding provisions for inaccessible or unsafe-to-monitor valves, extensions for repair beyond shutdown, and reconsidering the monitoring frequency or leak definition. Other comments were concerned with test methods and procedures, back-up systems, inspection and maintenance data, repair schedule, safety of monitoring relief valves, and alternative standards for valves.

2.4.2.1 Inaccessible Valves. Comment: Six commenters recommended that a separate monitoring requirement be provided for inaccessible (difficult-to-monitor) valves (IV-D-18; IV-D-21; IV-D-29; IV-D-30: IV-F-1; IV-D-13; IV-D-27: IV-K-1).

One commenter stated that some valves are inaccessible for safety reasons or because of elevation and/or configuration. As the commenter noted, many of these valves can be eliminated in an entirely new plant, but compliance with the proposed regulation may be difficult in an older plant. This commenter proposed that an alternative requirement be provided for inaccessible valves (IV-F-1).

One commenter estimated that platforms needed to provide safe access for routine monitoring purposes cost between $10,000 and $20,000 each. This cost, the commenter noted, is difficult to justify considering the small incremental control potentially achievable. The commenter recommended that inaccessible or difficult-to-access components be treated specially or exempted altogether (IV-D-18).

Another commenter noted that valves that are inaccessible without erecting scaffolding, climbing out on piping, or hanging from a ladder pose a safety hazard to the monitoring personnel. The commenter suggested that "accessible" be defined as "able to safely reach from the ground or an existing permanent platform," which would include 90 percent of the valves in a petrochemical facility (IV-D-30).

Another commenter suggested that an annual leak detection and repair program be specified for difficult-to-monitor valves (i.e., restricted access to valve bonnet or valves located on elevated pipe racks) as is specified in the proposed standard of performance for refinery VOC fugitive emissions (IV-D-13; IV-D-27).

Response: EPA acknowledges that some valves are difficult to monitor because access to the valve bonnet is restricted or the valves are located in elevated pipe racks. Difficult-to-monitor valves can be eliminated in new process units, but they may not be eliminated in existing process units. The proposed standard, therefore, has been amended to provide for difficult-to-monitor valves. The final standard defines difficult-to-monitor valves as valves that require elevating the monitoring personnel more than 2 meters above any permanent available support surface. The commenter's suggested definition expresses EPA's intention in requiring safe access to difficult-to-monitor valves. EPA's definition includes specifically the safe use of step ladders, which may be required to elevate monitoring personnel under safe conditions, but scaffolds will not be required. For existing fugitive emission sources of benzene, EPA is requiring an annual leak detection and repair program for valves that are difficult to monitor. An owner or operator, therefore, will designate valves that cannot be safely monitored by the use of step ladders and will comply with an annual leak detection and repair program.

2.4.2.2 Unsafe-to-Monitor Valves. Comment: One commenter recommended that valves unsafe to monitor because of extreme temperature, pressure, or explosion hazard be inspected by a plan developed by each refinery (IV-D-13; IV-D-27).

Response: EPA recognizes that some valves are unsafe to monitor based on the judgment of the owner or operator. Unsafe-to-monitor valves are defined as those that expose monitoring personnel to imminent hazards from temperature, pressure, or explosive process conditions. EPA does not believe valves in benzene service will be unsafe to monitor. Although unsafe-to-monitor valves in benzene service may not exist, they could not be eliminated if they do exist; thus EPA is giving special consideration for unsafe-to-monitor valves. The final standard will require an owner or operator to prepare a plan that defines a leak detection and repair program conforming with the routine monitoring requirements of the standard as much as possible, except monitoring should not occur under unsafe conditions.

2.4.2.3 Extensions for Repair Beyond Shutdown. Comment: Two commenters recommended that the proposed leak repair requirements include extensions for repair beyond a process unit shutdown in limited situations. The commenters listed some of these situations, which include obtaining replacement or spare parts not normally in stock, replacement of the entire valve assembly, items requiring long delivery times, or manufacturer delays in supplying parts. The commenters recommended that industry be allowed extensions of repair beyond a process unit shutdown in these situations (IV-F-1; IV-D-13; IV-D-21; IV-D-27). One of the commenters further recommended that the provision for delayed repairs should apply to valves as well as all other components (IV-D-21).

Response: In the proposed standard, delay of repair was allowed for leaks that could not be repaired without shutting down a process unit. In general, these leaks would be repaired at the next scheduled unit shutdown. EPA recognizes that in certain situations the lack of spare parts might prevent repair of all leaking valves during a unit shutdown. Spare parts for valves can usually be stocked so that all leaks that can not be repaired without shutting down the unit can be repaired during the shutdown. Spare parts include packing gland bolts and valve packing material. In a few instances, the entire valve assembly would need to be replaced. In the final regulation, EPA is adding provisions to allow delay of repair beyond a shutdown for valves that require replacement of the entire valve assembly, provided that the owner or operator can demonstrate that sufficient stock of spare valve assemblies has been maintained and that the supplies have been depleted.

Another new provision is added to the regulation to allow delay of repair for valves if the owner or operator shows that leakage of purged material due to immediate repair is greater than the fugitive emissions that are likely to result from delay of repair. EPA does not expect this situation to occur often. Based on an engineering analysis, EPA has estimated the emissions from draining a line to allow immediate isolation of a valve for off-line repair for comparison with estimated emissions that are likely to result from allowing a valve to continue leaking (IV-B-20). This analysis is based on a leaking control valve that has inlet and outlet block valves and a bypass loop to allow continued operation of the process unit. Assuming that all of the benzene trapped between the inlet and outlet block valves is released to atmosphere when the control valve is isolated from the process (a worst-case situation), EPA estimated that for an average size process line 0.077 meters (3 inches) in diameter and 2 meters (6 feet) in length, 8.35 kg of benzene would be emitted. This 8.35 kg represents about 4 days of benzene emissions if the valve were allowed to continue to leaking. EPA would not consider allowing delay of repair for this valve to be reasonable. EPA believes this delay of repair provision for valves would be reasonable for only a fairly large and long process line or process vessel and for a fairly long time until the next process unit shutdown. For example, EPA roughly estimated the maximum volume of benzene leaking over a 180-day period and compared it to the corresponding maximum line length and diameter of pipe. The emissions resulting from a valve leaking 180 days (367 kg of benzene) corresponds with a pipe length of 22 meters (73 feet). In general, times until shutdowns, pipeline length, and pipeline diameter are smaller than these estimates; thus, use of this provision will be infrequent. Additionally, it is unlikely that all of the benzene purge would be emitted to atmosphere. Some plants purge to a closed-drain system or other systems to reduce personnel exposure to short-term, high concentrations of benzene like those resulting from draining a process line. For this reason, emissions estimated above for immediate valve repair are likely overstated. Consequently, delay of repair for valves is reasonable if the valves cannot be repaired without a shutdown. This situtation is expected to occur very infrequently. The final standard allows a plant to determine whether off-line repair emissions from draining a line are greater than emissions resulting from repair delay ("continued leakage"). If this demonstrates that emissions from draining a line are greater than emissions from allowing a valve to continue leaking until the next process unit shutdown, then delay of repair will be allowed.

A definition of "process unit shutdown" has also been added to the regulation to clarify EPA's intent of avoiding extended delays in returning a process unit to production if the unit shuts down briefly due to unforeseen circumstances. Delay of repair beyond an unforeseen process unit shutdown will be allowed if this shutdown is less than 24 hours in duration (Docket No. A-79-32-IV-J-3). Repair of leaking equipment for which repair has been delayed would be required at the next scheduled process unit shutdown.

As part of the repair requirements, EPA is clarifying its intent for spare equipment that does not remain in benzene service. Delay of repair of equipment for which leaks have been detected will be allowed for equipment that is isolated from the process and that no longer contains benzene in concentrations greater than 10 percent. This equipment must be purged to a system that complies with the requirements for closed-vent systems and control devices. Emissions from equipment can be collected and transported through a properly designed and installed closed-vent system as verified by Reference Method 21. Control devices allowed by EPA that destroy benzene equipment leaks are flares, enclosed combustion devices, and vapor recovery systems that will achieve at least a 95 percent reduction efficiency of benzene emissions. As discussed in Section 2.4.1.1, smokeless flares operated with a flame present may be used. Enclosed combustion devices are required to be designed to provide a minimum residence time of 0.50 seconds at a minimum temperature of 760°C, and vapor recovery systems are required to operate with an efficiency of 95 percent or greater.

2.4.2.4 Monitoring Frequency. Comment: Four commenters recommended that the monitoring frequency be reconsidered. Various reasons for the recommended changes were cited (IV-D-13; IV-D-20; IV-D-21; IV-D-27; V-F-1; IV-K-1). Another commenter supported EPA's choice of a monthly inspection frequency of equipment that may leak and stated that longer intervals would allow large leaks to go undetected for 6 months or a year (IV-D-31).

One commenter stated that the monthly monitoring requirement is excessive and partially based on assumed factors that are not supported by any data. The commenter recommended that data from on-going studies be considered, that the basis for the monitoring frequency be re-evaluated, and that the monitoring frequency be established on a cost-effective basis (IV-D-13, IV-D-27).

One commenter stated that quarterly leak detection monitoring is too frequent when considered in light of the small potential losses. The commenter recommended that the Agency require no greater frequency than annual leak detection monitoring (IV-K-1).

Another commenter recommended that a true quarterly monitoring program rather than a hybrid (monthly/quarterly) program be implemented by the proposed regulation for the following reasons (IV-F-1). The commenter believed that leak frequency data developed for the chemical industry is significantly different from that developed for the petroleum refining industry. In the absence of representative data, the commenter further believed that it is not logical to assume anything other than a linear leak occurrence/recurrence rate with time and a recurrence rate that varies in proportion to occurrence. The commenter felt that, without any field data, EPA had to use engineering judgment to conclude that more frequent monitoring will result in finding four times as many leaks in valves monitored monthly rather than annually and twice as many leaks if monitored monthly rather than quarterly. The commenter felt that the proposed monthly/quarterly monitoring requirements are not cost effective. A directed maintenance program during a shutdown will yield optimum results at minimum cost. The commenter recommended that no further monitoring be required on a piece of equipment that can not be repaired on-line until just before shutdown, at which time the leak can be fixed. The commenter also believed that monitoring and sampling requirements are excessive for pumps, suggesting that quarterly monitoring be required (IV-D-21).

Response: Since proposal, EPA has re-evaluated leak detection and repair cost data for valves and pumps using the model developed specifically for leak detection and repair programs (Appendix B). As discussed in Section 2.3, EPA has concluded that monthly leak detection and repair is reasonable for valves and pumps because the results from the model indicate that the costs of monthly programs for valves and pumps are reasonable. The costs for various leak detection and repair intervals are presented in Appendix A.

Monthly/quarterly leak detection and repair programs were examined because EPA considered this program to provide the most reasonable approach in implementing monthly monitoring. Based on the results of the LDAR model (see Appendix B), however, the monthly/quarterly program does not achieve as much emissions reduction as the monthly program. EPA is allowing the use of the monthly/quarterly leak detection and repair program, however, because the monthly/quarterly program as designed by EPA would provide better control than the control estimated by the LDAR model. The intent is to require monthly monitoring for valves that leak often or occasionally but quarterly monitoring for valves that do not leak very often.

The comment regarding quarterly versus annual leak detection and repair for pumps (IV-K-1) applies to the level of control suggested by the petroleum refinery control technique guidelines, or Regulatory Alternative II, in the BID for the proposed standard. As discussed above, after considering the comment, EPA did not select this control level for the final standard.

2.4.2.5 Leak Definition. Comment: Three commenters disagreed with the 10,000 ppmv level of leak detection set by EPA (IV-D-21; IV-D-24; IV-D-31). One of the commenters felt that the criterion of 10,000 ppm VOC is unduly restrictive in the monitoring requirements for pipeline valves, open-ended valves, and existing pumps and compressors. This value corresponds to only 2,900 ppm of benzene according to the commenter. Since the concentration is related to a rate and benzene emissions were not measured in the EPA studies, the commenter noted this rate may be more restrictive than that allowed under the proposed VOC fugitive emission regulation (IV-D-24).

Another commenter felt that the 10,000 ppm cut-off should be lowered and that EPA is not justified in exempting all leaks below 10,000 ppm from the repair requirement. The commenter expressed concern that EPA apparently is not certain that making repairs in the 1,000 to 10,000 ppm range will result in net increases in emissions. The commenter contended that the BID for the proposed standard, pages C-16 through C-17, shows that most repaired leaks result in lower emission levels. The commenter asserted that EPA should have examined whether an intermediate cut-off (for example, 2,500, 5,000, or 7,500 ppm) would better maximize net reductions (IV-D-31).

Response: The first commenter states that the 10,000 ppmv leak definition is too low. The leak definition is not based on acceptable or unacceptable emission rates. Instead, EPA selected a value based on seal failure as a result of testing fugitive emission sources. In addition, most organic concentrations are either very low (much less than 10,000 ppmv) or very high (much greater than 10,000 ppmv), so small changes in concentration are not meaningful. The 10,000 ppmv leak definition is the highest level that a typical organics monitoring instrument can detect directly. In order to measure higher concentrations with the instruments most commonly used, additional care and calibration for devices such as dilution probes are required to obtain accurate results.

The Maintenance Study (IV-A-6) examined the effects of simple on-line maintenance (tightening bolts) for valves using an action level of 10,000 ppmv. A repair efficiency of only 29 percent was found as a result of this maintenance. However, this efficiency corresponded to a 71 weight percent reduction in emissions. At a higher leak definition, the repair efficiency may be increased, but a lower weight percent reduction in emissions would result. Therefore, the 10,000 ppmv leak definition was selected instead of a higher level.

The second commenter correctly pointed out that there would be only a potential for a net increase in emissions if an action level between 1,000 and 10,000 ppm were selected. A net increase in mass emissions might result if higher concentration levels result from attempted repair of a valve with a screening value between 1,000 and 10,000 ppm. Many leaks can be repaired at concentrations less than 1,000 ppm. However, the key criterion in selecting a leak definition is the mass emissions reduction achievable. Any leak definition chosen would only be an indicator of whether a source was emitting benzene in quantities large enough to warrant repair. In this regard, a leak definition of 10,000 ppm accomplishes this goal. Based on the findings of the Maintenance Study, the 10,000 ppm leak definition results in an overall 71 weight percent reduction of VOC emissions using simple on-line maintenance. EPA believes that there is only a slight potential for emission reduction for sources having benzene concentrations between 1,000 and 10,000 ppmv; therefore, using a lower leak definition would not increase reductions in emissions significantly. This potential is offset by a chance that increases in emissions may occur by attempting maintenance at levels lower than 10,000 ppmv, thereby negating the benefit of using a leak definition around 1,000 ppm. Therefore, a leak definition of 10,000 ppmv was selected instead of a lower level.

2.4.2.6 Spare Equipment. Comment: One commenter recommended that greater back-up requirements are needed to enable quick repairs at significant emission points that otherwise cannot be readily repaired without shutting a plant down. According to the commenter, back-up systems would be practical and enable quick leak repair for control valves, block valves, safety/relief valves, pumps, and compressors. The commenter suggested as an example that piping could often be built in series for two pumps, and a spare pump could be exchanged among leaking pump sites (IV-D-31).

Response: In allowing delays of repair, EPA recognizes that there may be instances where equipment cannot be repaired on-line. Delay of repairs are allowed mainly if a process unit must be shutdown. Back-up systems can help reduce these shutdowns, but having a complete set of spare equipment is not practicable. Pumps that require a process unit shutdown for repair already have a spare. (Every pump is assumed to be spared in the cost impact analysis for the model units.) Thus, requiring spares for all pumps would not be needed and would increase emissions of benzene with little, if any, benefit. For valves, spare valves might provide repairs for sources that otherwise would continue to leak. However, because EPA believes the number of these continuing leaks to be small, the increase in emissions due to the extra valves is not offset by the decrease in emissions due to repairing those that continue to leak. Since equipment specifications (not leak detection and repair) are required for pressure relief devices and compressors, spares for these components are not appropriate.

2.4.2.7 Data from Control Techniques Guideline. Comment: One commenter believed that EPA underestimated numbers in its control techniques guideline for fugitive emission inspection and maintenance data (e.g., number of valves that can be tagged per day, number of valves that can be inspected per day, cost of repairing leaks, number of field people required for monitoring, the number of clerical people needed to transmit data and prepare reports, amount of supervision to conduct the program, amount of emissions abated) (IV-D-20).

Response: The commenter is referring to the control techniques guideline (CTG) document entitled Control of Volatile Organic Compound Leaks from Petroleum Refinery Equipment (II-A-10). The estimates of leak detection and repair data presented in the CTG are based on actual data supplied by industry. The commenter appears to be questioning the costing procedures used in the proposed standard because they were similar to the procedures, used in the CTG. For example, the estimated number of valves that can be inspected, manhours needed for leak detection and repair, and subsequent costs are based on actual studies of monitoring and maintenance program manpower requirements performed by Exxon (II-D-28), general survey practices followed by Phillips Petroleum Company, and the State of California Air Resources Board (II-I-35).

The basis for the leak detection and repair costs for the final standard is presented in the AID (IV-A-24), except an hourly labor rate of $15.50 was used (based on 1979 estimates). The labor rate estimate included wages plus 40 percent of wages for labor-related administrative and overhead costs (Refinery CTG estimates). Administrative and support costs to implement the regulation were estimated to be an additional 40 percent of monitoring and maintenance labor (Refinery CTG estimates). Two monitoring instruments per model unit were assumed to be required for the leak detection and repair program at a cost of $4,300 per instrument. In addition, an annual maintenance and calibration cost of $2,800 was assumed for the monitoring instruments (Docket No. A-79-27-II-A-10 and A-80-44-II-E-7). EPA considers these estimates for the leak detection and repair program to be reasonable.

2.4.2.8 Repair Schedule. Two commenters submitted remarks concerning the schedule for repairing leaks once detected.

Comment: One commenter felt that the timing requirements for seal repair are too restrictive, stating that a fixed time schedule will reduce the productivity of operating facilities for no good reason. The commenter noted that in most plants, a catastrophic seal failure will be repaired quickly as standard operating practice. In addition, the commenter suggested that if the benzene leak rate of liquid dripping from a seal is not excessive and does not require repair, the operator should not take action until a normal shutdown for routine maintenance or until the benzene leak rate becomes excessive (IV-D-24).

The other commenter, however, disagreed and argued that a 15-day repair time is too long, especially for large leaks. The commenter believed that in most cases firms should have readily at hand both the personnel and the equipment to effect repairs. The commenter agreed with a first attempt at repair within 5 days and added that it should be the maximum allowed except in carefully specified situations (IV-D-31).

Response: The 15-day repair time for valves, pumps, compressors, and other fugitive emission sources (for example, pressure relief devices in liquid service, flanges and other connectors) is considered adequate for repair of all of these sources but critical valves that cannot be bypassed. Provisions have been made for delaying these valves until the unit is shutdown. The 15-day interval was selected because it provides time for better determination of methods for isolating pieces of leaking equipment when equipment isolation is needed for repair beyond simple field repairs. The 15-day repair interval allows more efficient handling of repair tasks while maintaining an effective reduction in fugitive emissions. Longer repair intervals provide less effective reduction in emissions and do not substantially improve the efficiency in handling repair tasks. Shorter repair intervals recommended by the second commenter could cause scheduling problems in repairing valves and pumps that need to be removed from the process for repair. The 15-day interval provides the owner or operator sufficient time to determine what spare parts are needed for these isolated valves and pumps and time for flexibility in scheduling repair for these valves and pumps. The first commenter is referring to the weekly visual inspection requirement for pump seals. The commenter does not define what constitutes an "excessive" leak rate of benzene dripping from a seal. If any owner or operator does not take action to repair a pump that shows signs of dripping liquids, then a potentially large leak and loss of valuable product would continue unnecessarily. The weekly visual inspection requirement for pump seals is a measure towards preventive maintenance and a supplement to monitoring, and it is common sense. As stated in Chapter 4, page 4-6, of the BID for the proposed standard, observation of liquid leaking along the pump shaft indicates a seal failure and signals the need for repair.

2.4.2.9 Valve Maintenance. Two commenters questioned specific maintenance (repair) requirements for valves.

Comment: One commenter clarified a public hearing comment by recommending that the concept of follow-up maintenance on valves should be explained in more detail. In general, however, the commenter agreed that the valve maintenance procedure is acceptable, that is, an attempted repair on a valve that does not bring the concentration below 10,000 ppm would be followed by tagging the valve for repair at the next turnaround. The commenter recommended, however, that EPA explain this concept in more detail (IV-D-21).

Response: As discussed in the preamble to the proposed standard, an initial attempt to repair a leaking valve should be accomplished as soon as practicable, but no more than 5 days after detection of the leak. Attempting to repair the leak within 5 days will help maintenance personnel identify the leaks that can not be repaired with simple field repair or without shutdown of the process unit. The initial repair attempt may consist of simple repair, which can be performed as leaks are detected (undirected repair), or may be scheduled for attention at a later time, not to exceed the 5-day limit. The initial attempt at simple valve repair shall include, but not be limited to, tightening of the valve stem packing gland, tightening or replacement of valve bonnet bolts, and in some cases, application of leak sealant.

Valves that continue to leak after simple field repair attempts must be repaired within 15 days following initial leak detection. The 15-day interval provides time for properly isolating leaking valves that require more than simple field repair. The 15-day interval also provides the owner or operator with sufficient time for determining precisely which spare parts are needed and flexibility in scheduling repair for leaking valves.

Delay of repair beyond 15 days will be allowed for leaks that can not be repaired without shutting down a process unit. In general, these leaks will be repaired at the next unit shutdown. Leaking valves will not be allowed to operate beyond process unit shutdown, except in unique cases where replacement of entire valve assemblies is required. In these unique cases, the valve will be allowed to leak beyond the scheduled process unit shutdown, provided the owner or operator can demonstrate that a sufficient stock of spare valve assemblies had been maintained. In addition, delay of repair beyond 15 days will be allowed for leaks if the unit shutdown is less than 24 hours in duration.

Comment: The other commenter suggested that more emphasis should be placed on preventive maintenance procedures and cited as an example the possibility of replacing the packing in valves at regular intervals before it becomes brittle and subject to leakage (IV-D-31).

Response: Certainly the ideal way to eliminate benzene fugitive emissions is to prevent them from occurring altogether. Some of the equipment and performance requirements in the final standard provide for this where possible. One means of reducing leaks from valves is through scheduled preventive maintenance. This type of program would not, however, eliminate leaks due to the numerous variables affecting the equipment leak occurrences. General maintenance is already performed in process units covered by the standard but, while requiring routine maintenance would result in some extra emission reductions, the extra effort is not justified.

For example, a new valve stem packing may be loose, or the seal of a valve bonnet flange may be imperfect, thereby allowing leaks. These types of leaks would not be corrected by simple replacement of valve stem packings at specified intervals. Monitoring would be necessary to detect and repair leaks not resulting from valve stem packing deterioration. Monitoring at specified intervals will also detect leaks due to premature valve stem packing failure. Further, the alternative performance standard for valves allows less than 1.0 percent of the valves to leak at any time. This performance standard is designed to provide incentive to plant owners or operators to perform preventive maintenance in order to avoid some of the costs of recurrent monitoring. The selection of the alternative performance standard for valves is discussed in Section 2.4.11.

2.4.2.10 Safety of Monitoring Relief Valves. Comment: One commenter questioned the safety of requiring all safety/relief valves to be monitored, stating that if a process upset occurs while monitoring one of these valves, the valve would relieve, and serious injury or death could result. The commenter added that the only potential leak area on a safety valve is the open end of a valve designed to vent to atmosphere. The commenter recommended, therefore, that EPA eliminate this monitoring requirement on safety/relief valves (IV-D-30).

Response: The standard for new and existing pressure relief devices in gas service in the petroleum refining and chemical manufacturing industries requires an annual performance test using Reference Method 21 to verify that the device is maintained at no detectable emissions. The annual testing is similar to testing done by EPA and EPA contractors in collecting data for the standard and similar to testing required by States under implementation plans. These tests could be scheduled during periodic inspections of pressure relief devices, which are typical of many industry safety practices. Monitoring should be done by personnel who understand the precautions needed when monitoring pressure relief devices. If a pressure relief device is likely to relieve when monitoring occurs, then special precautions, such as monitoring of process conditions (temperature and pressures), should be taken by the process unit operator. Based on EPA's experience in collecting data for pressure relief devices, monitoring of these devices can be done safely.

In addition to the annual performance test, pressure relief devices must be checked within 5 days after each relief discharge to demonstrate the attainment of the no detectable emissions limit. When a relief valve/rupture disk system is used, EPA anticipates the rupture disk would need to be replaced after each relief discharge to ensure the standard is achieved. The relief valve would be monitored when the system is put back in service. For a pressure/relief valve that is equipped with soft-seat o-rings that can achieve the standard, the relief valve would be required to be monitored after each relief discharge (within 5 days) to demonstrate attainment of the no detectable emissions limit. However, the pressure relief device does not need to be monitored (annually or within the 5-day limit) if it is piped to a closed vent system connected to a control device (e.g., flare header to flare).

2.4.2.11 Alternative Standards for Valves. Comment: One commenter recommended that the alternative standards for valves in the refinery VOC fugitives NSPS be incorporated into the proposed benzene fugitives NESHAP. For example, the commenter suggested that the 2 percent allowable number of leaks and the skip-period leak detection/repair program could be incorporated into the proposed benzene fugitives NESHAP (IV-D-13; IV-D-27).

Response: EPA realizes that the emission reduction and annualized cost of the leak detection and repair program depend in part on the number of leaking valves that are detected during monitoring. If very few valve leaks are detected in a process unit, then the amount of benzene that could be reduced by the program for valves is much smaller than the amount that could be reduced in a unit having more leaks. Additionally, the annualized cost of the leak detection and repair program would be larger for a unit with fewer leaks than in a unit with more leaks, because the annualized cost includes a recovery credit based on the amount of benzene reduced by the program. Thus, the annualized cost per megagram of benzene emission reduction for the leak detection and repair program varies with the number of valves which leak within a unit.

For example, a monthly leak detection and repair program for valves in benzene service typically results in an annualized credit of about $20 per valve and achieves an annual benzene emission reduction of 0.09 Mg per valve for an average-size process unit. In contrast, for an average-size process unit with 1.0 percent of the valves leaking on the average, a monthly leak detection and repair program results in an annualized cost of about $8 per valve and achieves an annual emission reduction of 0.004 Mg. For an average-size process unit with 0.5 percent of the valves leaking on the average, a monthly leak detection and repair program results in an annualized cost of about $9 per valve and achieves an annual emission reduction of 0.0011 Mg (IV-B-5).

EPA judges that the emission reduction and annualized cost relationship is unreasonably high for process units having on the average fewer than about 1 percent of valves leaking (IV-B-5). Based on this judgment, an allowable percent of valves leaking was determined that reflects the average of about 1 percent of valves leaking, as discussed below.

An allowable percent of valves leaking was selected that included the variability inherent in leak detection of valves. The variability in leak detection of valves can be characterized as a binominal distribution around the average percent of valves leaking. An allowable percent of valves leaking of 2 percent, to be achieved at any point in time, would provide an owner or operator a risk of about 5 percent that greater than 2 percent of valves would be found leaking when the average of about 1 percent was actually being achieved. EPA also considered the range of percent leaking valves within process units and found that at about 2 percent a break between low-leak plants and higher leak plants occurred. Based on these considerations, EPA selected an allowable percent of valves leaking of 2 percent.

EPA is providing two alternative standards that would exempt valves in benzene service within process units from the required monthly leak detection and repair program. Plant owners or operators may identify and elect to achieve either of the alternative standards. The alternative standards will allow owners or operators to tailor benzene fugitive emissions control programs to their own operations. An owner or operator will report which alternative standard he or she had identified and elected to achieve.

The first alternative standard will limit the maximum percent of valves leaking within a process unit to 2 percent. This type of standard will provide the flexibility of a performance standard. An industry-wide performance standard which could be achieved by all process units was not possible for valves. This was due to the variability in valve leak frequency and variability in the ability of a leak detection and repair program to reduce these leaks among all process units within the industry. However, this alternative standard will allow any process unit the option of complying with an allowable percent of valves leaking for a particular unit. Choosing this alternative standard will allow for the possiblity of different leak detection and repair programs and substitution of engineering controls at the discretion of the owner or operator. This alternative standard will also eliminate a large part of the recordkeeping and reporting associated with the monthly leak detection and repair program for valves.

Performance tests as specified in 40 FR Part 61 require three runs. Three runs for performance tests to determine the percent of valves leaking are unnecessary. Thus, performance tests are exempt from Part 61 in the final standard. However, this alternative standard will require a minimum of one performance test per year. Additional performance tests could be requested by EPA. If the results of a performance test showed that greater than 2 percent of the valves leak, the owner or operator could be cited for violation of the standards. Inaccessible valves, which would not be monitored on a routine basis under §61.242-7(h), would be included in the annual test since an annual test of these valves is not considered unreasonable.

In certain circumstances, an owner or operator may want to request a waiver of future tests as provided in the General Provisions of 40 FR Part 61. This will provide flexibility for plant owners and operators where, for whatever reason, routine leak detection and repair is not needed to effectively control emissions. This will include plants that use superior equipment, plants that have effective occupational safety and health programs, or plants that simply do not leak for unknown reasons. Based on performance tests that demonstrate the achievability of the 2 percent standard and information that indicates that this standard would be achieved on a continuing basis, EPA could waive the annual performance tests.

The second alternative standard will allow the use of skip-period leak detection for valves in benzene service. Under skip-period leak detection, an owner or operator could skip from routine leak detection for valves to less frequent leak detection. This skip-period leak detection program will require that a performance level of 2 percent be achieved on a continuous basis with more than 90 percent certainty. An owner or operator will choose one of two skip-period leak detection programs for valves and then implement that program. The first skip-period leak detection program could be used when fewer than 2 percent of the valves had been leaking for two consecutive quarterly leak detection periods. The first skip-period leak detection program will allow an owner or operator to skip every other quarterly leak detection period; that is, leak detection can be performed semiannually. Under the second skip-period leak detection program, if fewer than 2 percent of the valves had been leaking for five consecutive quarterly leak detection periods, the owner or operator may skip three quarterly leak detection periods; that is, leak detection can be performed annually. When more than 2 percent of valves are found to leak, monthly leak detection will be required to be resumed.

2.4.2.12 Need for Leak Detection and Repair Requirements.

Comment: One commenter noted that, in general, the leak monitoring and repair program requirements are excessive, duplicate previous regulations for hydrocarbon fugitive emissions, and only create unnecessary paperwork for industry and the regulatory agency. The commenter noted that at its refineries, the benzene handling units are manned 24 hours a day, 7 days a week by qualified operators whose duties include the constant checking and observing of all equipment in their assigned area for fugitive emissions. In addition, the commenter stated that it has installed a gas chromatograph that continually records the level of benzene in the ambient air at the complex. The commenter feels that these combined measurements are more than adequate to prevent benzene fugitive leaks from going undetected (IV-D-20).

Response: EPA recognizes that some refineries and chemical plants already have programs that include checking and recording ambient benzene levels. These programs, however, are not uniformly found in all refineries and chemical plants. In addition, EPA has found that gas chromatograph systems in general are highly subjective and rely on operator diligence to a very high degree. The leak detection and repair programs that are included in the final standard are intended to identify benzene leaks that may not be detected by visual, audible, or olfactory means, which tend to be very subjective. To the extent that programs already in place provide effective emission reduction, EPA is allowing plant owners or operators to select one of two alternative standards for leak detection and repair of valves. EPA has given the owners or operators the flexibility to tailor fugitive emissions control programs to their own operations. (See Section 2.4.11 for a discussion of the alternative standards for valves.)

2.5 RECORDKEEPING AND REPORTING

Several commenters raised issues pertaining to both reporting and recordkeeping requirements. Others addressed reporting and recordkeeping as separate topics.

2.5.1 Recordkeeping

Comment: One commenter felt that indicating a leak with a log entry is preferable to tagging every leak and leaving the tag in place for three months, since many leaks will be repaired as they are found (IV-D-13).

Response: A tag is not specifically required by the standard; only some sort of identification is required, and a log entry is acceptable as long as the equipment component can be identified from the log entry. Some identification would be needed for all fugitive emission sources of benzene in the leak detection and repair program. This distinguishes these sources from sources complying with other requirements. Further, identification of a leak is necessary to enable follow-up inspections to be made when using the allowance for quarterly monitoring of certain valves. Valves must be identified as leakers for two consecutive months after the leak is found before they can be monitored quarterly. Thus, even though a tag is not required, some sort of identification is required.

Comment: One commenter suggested that, in order to eliminate duplicate records for the leak detection and repair program, EPA should allow the use of existing automatic data systems to maintain the required records along with the other plant operating and maintenance records. The commenter added that maintenance job orders to repair fugitive emission leaks could be coded to allow them to be retrieved from the computer data bank (IV-D-16).

Response: The owner or operator is allowed to maintain records in any desired form. The only stipulation is that all records must be true, accurate, and readily available for EPA inspection. The use of automatic data systems to maintain records is allowed.

2.5.2 Reporting

Comment: One commenter felt that the reporting requirements are purely for the ease of enforcement purposes, for data collection purposes, or require the submittal of duplicate information. The commenter suggested that EPA either delete the requirements or justify the need for the routine reporting requirements in determining compliance with the standard (IV-F-1).

One commenter suggested that after submitting the initial report, plants should report only changes in the number of valves or leaks detected and repaired (IV-D-11). Two commenters recommended that only leaks not repaired should be reported quarterly (IV-D-13; IV-D-18). One commenter stated that reporting the number of valves in each process unit is unnecessary since the number rarely changes (IV-D-13). One commenter added that records of details of unsuccessful repair attempts, while possibly of interest to the owner or operator, should not be made a reporting requirement (IV-D-18).

Response: Effective enforcement of the standard is necessary especially in light of the hazardous nature of benzene. Reporting requirements are very helpful for efficient and effective enforcement of the standard. Contrary to what the commenter suggests, the requirements are not made purely for the ease of enforcement or for the purpose of data collection; nor are the reporting requirements duplicative. Reports will be used in conjunction with records and inspections to enforce the standard.

In response to the comments on reporting requirements, EPA has reduced the amount of information that must be reported by the plant owner or operator. The information required in reports is the same information that a plant manager would likely want to evaluate for his or her program. The report will include the number of leaks that occurred within the process unit during the reporting period, the number of leaks that could not be repaired within 15 days, and the general reasons for unsuccessful or delay of repair past the 15-day period.

The requirement to report reasons for unsuccessful or delay of repair is necessary to allow EPA to assess whether the owner or operator is making reasonable attempts at repair and understands the workings of the standard. EPA expects that delays will occur only because repair would result in process unit shutdown. Such delays can be readily explained by the owner or operator. Since EPA does not expect many of these delays to occur, EPA considers reporting the reasons for them to be reasonable.

The requirement to report the number of leaks found will assist EPA in determining whether or not the number of leaks not repaired within 15 days indicates reasonable attempt at repair. EPA will gauge the significance of the number of leaks not repaired within 15 days in relation to the number of leaks found.

EPA has decided to reduce the reporting requirements from quarterly to semiannual reporting. This reduction is made in order to reduce reporting costs and orient the focus of the reports towards revealing longer-term trends in leak repair programs. The objective of the enforcement program is to single out plants that, over the long-term, repair leaks with less efficiency than most other plants. Such long-term trends are best identifiable over 6-month periods. Quarterly reporting would be more frequent and more costly than necessary. Annual reporting would not be frequent enough because EPA enforcement personnel need to inspect plants before the plant records become outdated and less useful in helping to determine what has been occurring within the plant. Furthermore, EPA enforcement programs are planned 1 year in advance, and, since plant records may be destroyed after 2 years, it is likely that, under an annual reporting program, a plant inspection could not be planned until after plant records have already been destroyed.

In the proposed standard, EPA included a requirement to report leak location and I.D. number. This would have allowed EPA to determine whether certain fugitive emission sources of benzene in a plant were causing repeated problems. However, in order to reduce reporting requirements for industry and to reduce Agency review requirements, EPA has decided to eliminate leak location and I.D. number from the reporting requirements.

Since no reporting format is stipulated in the standard, reports required by other regulations may simply be photocopied and submitted in compliance with the benzene fugitive emissions standard as long as the report satisfies the informational requirements of §61.117.

The selected program involves minimum recordkeeping and a combination of inspections and reporting. This program is effective, efficient, reasonable, and should fit well with management of the standard by plant personnel. During the first 2 years of the program, the average annual burden of reporting and recordkeeping to industry would be about 20 person-years and would cost industry about $520,000 (IV-B-13). The burden is distributed among about 240 process units and, on an annual basis, represents about 1 person-month per process unit. At these costs, the program provides a reasonable level of compliance monitoring.

The selected recordkeeping requirements are the minimum that could be achieved without precluding the possibility of enforcing the standard. In addition, they represent the minimum level of documentation that plant personnel would require to evaluate implementation of the standard. Without retrospective data, inspections would be useless and reporting would be impossible. Reporting, being less expensive than inspections to both industry and EPA, is an effective mechanism for reducing the cost of inspections. Reports reduce the amount of time required to conduct inspections and make it possible to reduce the number of plants that need to be inspected. Plant inspections enable EPA to determine whether or not an owner or operator understands the standard and is in compliance with the standard. Inspections will be conducted when reported information is ambiguous or clearly indicates the need for an inspection. The reporting requirements will enable EPA to reduce the inspection rate and still maintain an effective compliance monitoring program.

A range of five alternatives was evaluated by EPA in selecting a reporting and recordkeeping program for the standard (IV-B-9). The alternatives, which represent different combinations of recordkeeping, reporting, and inspection levels of effort, were formulated to correspond with realistic programs suggested by industry and EPA personnel. The alternatives were evaluated in terms of their costs to industry and EPA and in terms of their effectiveness in maintaining a reasonable level of compliance monitoring.

Comment: One commenter noted that, although the proposed rules state that compliance with the reporting requirements of proposed §61.117 relieves the obligation to file a pre-construction approval application under 40 FR §61.07, nothing is said about the applicability of 40 FR §61.05. According to the commenter, 40 FR §61.05 provides that certain constructed or modified sources must obtain written approval of the Administrator, unless exempted by the President under Section 112(c)(2) of the Clean Air Act. The commenter suggested that if benzene fugitive emission rules are to be adopted, then the proposed 40 FR §61.117 should be revised to address the general prohibitions of 40 FR §61.05 as well as the specific application requirements of 40 FR §61.07 (IV-D-19).

Response: EPA agrees with this commenter. Accordingly, the provisions in §61.117 were expanded to include §61.05(a). The sole purpose of this provision is to reduce the administrative burden associated with minor changes to existing process units. Nothing in this provision should be interpreted to mean that compliance with the standard is not required. EPA is retaining review and approval of the construction of equipment in benzene service if it is associated with a new process unit. EPA's role in assuring effective control of hazardous air pollutants and the lack of an unreasonable administrative burden associated with the approval process convinced EPA to retain its review and approval process for new construction. Comment: Two commenters felt it is unreasonable to require plant managers to certify plant compliance with the standard when supervisory personnel are more familiar with compliance status (IV-D-16; IV-D-18). One of the commenters (IV-D-16) recommended that the manager sign a "knowledge and belief" certification that would best describe his function in reporting leak detection and repair requirements. The commenter explained that this certification would require the signer to personally examine the information to be submitted and to satisfy himself by inquiry to those immediately responsible for obtaining the information (i.e., supervisory personnel) that the information is true, accurate, and complete.

Response: According to the General Provisions for National Emission Standards for Hazardous Air Pollutants, Section 61.02, "owner or operator" is defined as any person who owns, leases, operates, controls, or supervises a stationary source. Under this definition, any supervisory personnel may be designated to certify plant compliance.

2.5.3 Miscellaneous Comments Addressing Both Recordkeeping and Reporting

Several commenters addressed reporting and recordkeeping together as a single topic.

Comment: Several commenters characterized the proposed reporting and recordkeeping requirements as excessive, unnecessary, cumbersome, or onerous for both industry and EPA (IV-F-1; IV-D-19; IV-D-20; IV-D-13; IV-D-21; IV-D-27; IV-D-2; IV-D-26). These commenters suggested reducing, streamlining, or justifying the proposed requirements.

Three commenters stated that the proposed reporting and recordkeeping requirements would duplicate already existing VOC control reporting and recordkeeping requirements (IV-D-19; IV-D-20).

One commenter made the following suggestions to reduce reporting and recordkeeping requirements for both industry and EPA: (1) that the reporting and recordkeeping requirements be abridged to include only pertinent data, i.e., (e) equipment identification, (b) ppm benzene leak detected, (c) date and individual detecting the leak, (d) date of repair, and (e) ppm benzene detected, if any, after repair; and (2) that each owner or operator should structure his/her own program, as required, to assure that needed repair is made within 15 days unless a shutdown is needed (IV-D-18). One commenter felt that the reporting and recordkeeping requirements were not developed within the guidelines of the Federal Reports Act, 44 USC §3501, which states that "information needed by Federal agencies shall be obtained with a minimum burden upon business enterprises .... Unnecessary duplication of efforts in obtaining information through the use of reports, questionnaires, and other methods shall be eliminated as rapidly as practicable." This commenter recommended that the proposed reporting and recordkeeping requirements be significantly reduced as required by the Federal Reports Act (IV-D-19).

Response: The reporting and recordkeeping requirements are designed to require absolutely the minimum level of industrial effort necessary to ensure effective implementation of the standard. Responding to the comments, EPA has reduced the reporting requirements as described in Section 2.5.2 of this document. Further reduction in reporting or recordkeeping requirements would eliminate their usefulness to EPA as a tool for determining compliance with the standard.

The rationale for recordkeeping under the standard is to document information relating to the use of specific equipment and the results of the leak detection and repair program. A log will be maintained for information pertaining to leaking sources. The log will contain the instrument identification number, the leaking source identification number, the date of detection of the leaking source, the date of the first attempt to repair the source, and the date of final repair. These requirements are less strenuous than those suggested by the commenter above in IV-D-18. For the purpose of enforcing equipment standards, records will be maintained of the dates of installation, startup, control equipment repair, control equipment modifications, and dates and descriptions of any control equipment failures. These records will be needed to provide information necessary to allow enforcement personnel to assess the effectiveness of implementation and maintenance of equipment standards.

The recordkeeping requirements in no way force the owner or operator to keep duplicate records. Records that are kept to comply with other standards may be used to comply with the benzene fugitive emissions standard as long as they satisfy the recordkeeping requirements in §61.116. Since the benzene fugitive emission standard does not require records to be kept in a particular form, any form will be acceptable as long as it contains the required information. Similarly, since no reporting format is stipulated in the standard, reports required by other regulations may simply be photocopied and submitted in compliance with the benzene fugitive emissions standard as long as the report satisfies the informational requirements in §61.117.

The comment suggesting that the owner or operator be allowed to structure his or her own program is unclear. Neither recordkeeping and reporting requirements nor leak detection and repair requirements dictate how the owner or operator should structure a repair program. The leak detection and repair program requires certain equipment to be used in certain cases, but the owner or operator may structure any program to achieve compliance with equipment requirements within 15 days of finding a leak.

2.6 COSTS

The cost of the proposed standard is discussed in Chapter 8 of the BID for the proposed standard, and its economic impacts are in Chapter 9. Since publication of the BID for the proposed standard, EPA estimates that the annualized cost of the standard is smaller than estimated at proposal. The main reason for this change is that the final standard is less stringent and accordingly less costly than the proposed standard. The BID for the proposed standard concludes that any potential price increases resulting from imposition of the proposed standard would be well under 1 percent, and that the profits and market positions of individual manufacturers would not be changed. In view of the lower cost of the promulgated standard explained below, these conclusions are underscored.

Comments and responses on Chapters 8 and 9 are assigned in this section to three categories: impacts on small facilities, cost effectiveness, and benefit-cost considerations. This categorization is not rigid because some comments are quite broad.

2.6.1 Impacts on Small Plants

This subsection addresses two principal concerns: the effect of the standard on small businesses, and the application of the standard to small-volume plants and to plants that use minor amounts of benzene or that use benzene intermittently.

The Regulatory Flexibility Act (Public Law 96-354, September 19, 1980) directs Federal agencies to pay close attention to minimizing any potentially adverse impacts of a standard on small businesses, small governments, and small organizations. Accordingly, EPA has reviewed the final standard in accordance with the Regulatory Flexibility Act. This standard will have no known effects on small governments and small organizations. It may affect some small businesses, but the impacts will be few and minor. Essentially all firms that will be required to comply with the standard either are not small businesses, or are subsidiaries of large firms. Because the overall net annualized (1985) cost of the standard is expected to be small ($100 thousand per year for new units and $400 thousand per year for existing units), there should be no adverse impacts on firms regardless of whether they are a small business.

In the analysis above, a small business is one that employs fewer than 750 persons. This level was set by the Small Business Administration (SBA) as a criterion for extending SBA loans and related assistance (13 FR Part 121, Schedule A). The definition applies to firms that manufacture cyclic crudes and cyclic intermediates, pharmaceuticals, and many other chemicals. The BID for the proposed standard lists 77 existing companies that may be affected by the standard. Most of these companies manufacture cyclic crudes and many other chemicals. With the possible exception of two companies, all of these firms either employ more than 750 persons, or are subsidiaries of large firms.

Comment: One commenter felt that the leak detection and repair requirements would impose substantial costs on small-volume users of benzene with no appreciable benefit to public health. According to the commenter, small-volume pipeline systems at pharmaceutical plants may contain several hundred valves that would need to be monitored monthly when in benzene service; the sporadic need for additional manpower to perform monitoring and clerical functions arising from recordkeeping requirements would have a major impact on operating expenses. The commenter added that the economic and administrative burden of complying with the standard would be heavy for small-volume users, as compared to large benzene production units, in proportion to the level of fugitive emissions from such facilities (IV-D-16).

Response: EPA is exempting most intermittent users or producers of benzene, such as pharmaceutical plants. As discussed in Section 2.8.1, EPA is exempting from the standard equipment at plant sites with a design usage rate of 1,000 Mg/yr or less. This is true regardless of whether benzene is produced or used. The 1,000 Mg/year exemption would exclude most research facilities, pilot plants, and intermittent users of benzene from the standard.

The possibility that pharmaceutical operations could be adversely affected by the final standard is very small. This is true for several reasons. First, most pharmaceutical plants use very little benzene. According to estimates contained in Market Input/Output Studies - Benzene Consumption as a Solvent (EPA-560/6-77-034, October 1978, p. 41), 1978 benzene consumption by pharmaceutical manufacturers was about 0.72 Gg. No companies consumed more than 1,000 Mg/year in 1978. The commenter states that they consumed about 325 Mg/year during 1981. Thus, it is unlikely that pharmaceutical operations would be affected by the standard. Second, benzene consumption by the pharmaceutical industry is declining rapidly. The market input/output study just noted estimates that consumption declined from 2.14 Gg in 1976 to 0.72 Gg in 1978, a decline of about 66 percent over the 2-year period. Third, the number of companies using benzene has also declined and is expected to continue to fall. For the 2-year period 1976 to 1978, the study estimates that the number of pharmaceutical companies using benzene declined from 10 to 5. And finally, even though pharmaceutical operations with a benzene throughput in excess of 1,000 Mg/yr are subject to the standard, they have substantial equipment inventories in benzene service and, therefore, emit benzene in enough quantity to warrant coverage by the final standard. EPA has reviewed the compliance costs for these operations and has concluded that these costs are reasonable (IV-B-17).

2.6.2 Cost Effectiveness

Some commenters claimed that the cost effectiveness was not calculated properly, or with the correct data. Others said that the cost effectiveness did not justify the standard. In these comments, "effectiveness" was measured in terms of emission reduction in some cases, and lives saved in others.

Comment: Two commenters felt that EPA had not selected the most cost-effective alternative as the basis for the proposed standard (IV-F-1; IV-D-8). One of the commenters (IV-F-1) said that industry's experience in air pollution abatement control programs has led it to conclude that capital costs in excess of $3,000 per magagram are not cost effective and should be rejected unless the other alternatives do not substantially achieve the necessary degree of control. The commenter concluded that the new SOCMI data indicate that the cost effectiveness is higher than the industry guideline of $3,000 per megagram.

Response: The basis for the standard is discussed in Section 2.3. Selection of BAT is based on an examination of the incremental cost effectiveness among various control techniques for each fugitive emission source. Whether to require more restrictive control than BAT is based on judging the risks remaining after BAT is applied and the cost of reducing these risks. Since proposal, EPA has selected a less restrictive standard than the one proposed in January 1981; consequently, the cost associated with the standard has decreased. The overall cost of the standard is expected to be less than $100/Mg of benzene and total emissions (benzene and other VOC) reduced. Even though some processes could experience an overall cost increase as a result of the standard, EPA considers the cost impact reasonable.

In response to the commenter and as discussed in Sections 2.3 and 2.8.4, EPA based emission estimates on refinery emission factors rather than on SOCMI emission factors because recent benzene-specific emission data from refineries and chemical plants are more similar to refining units than to SOCMI units. Therefore, the commenter's conclusion that the new SOCMI data (discussed in the AID, EPA-450/3-82-010) indicating that the cost effectiveness is higher than the industry guideline of $3,000 per megagram is not based on the same emission estimates used by EPA. However, using capital cost as the basis for cost effectiveness as the commenter did, (which is conceptually difficult to interpret in that there is no time period in the numerator while the denominator is on an annual basis) costs are considerably lower ($930/Mg of benzene for new sources and $1,100/Mg of benzene for existing sources) than the commenter's guideline of $3,000 per megagram. It is unclear how the commenter estimated "operating costs." Using net annualized costs, however, the overall cost effectiveness for the standard is less than $100/Mg of benzene and total emissions (benzene and other VOC) reduced.

Table 2-5 presents the revised annualized model unit control costs and savings for the standard, based on the control techniques discussed in Section 2.3. Table 2-6 presents the revised 1985 nationwide costs of the standard for both existing and new units.

Comment: One commenter said that EPA should investigate the incremental cost effectiveness of each discrete control requirement, and not the cost effectiveness of arbitrarily combined groups of control alternatives (IV-D-27).

Response: Selection of the final standard is based, as requested by the commenter, on an incremental cost-effectiveness analysis of each discrete control requirement.

Comment: One commenter felt that cost effectiveness dictates that Alternative IV at a minimum, or preferably Alternative V, should have been selected instead of Alternative III in order to fulfill the mandate of Section 112. This judgment is based on the commenter's observation that the net price increase would be less than one-fourth of 1 percent in benzene prices for Alternative IV and less than 4 percent for Alternative V. The commenter considered this a "trivial price to pay for saving additional lives," noting that, in rulemaking on the vinyl chloride standard in 1975, EPA decided that a price impact as high as 10 percent would have been acceptable. The commenter added that cost estimates are usually exaggerated, and firms often develop innovative, cheaper compliance techniques (IV-D-31).

Response: EPA has selected the final standard after considering whether the incremental risk reduction that would be achieved by applying additional control beyond BAT warrants the incremental cost. As explained in Section 2.3, EPA made the decision not to require additional control. EPA's rationale for selecting standards under Section 112 is discussed in EPA-450/5-82-003.

Comment: One commenter stated that the benzene standards involve minimal emissions and minimal population risk concerns at very great costs for implementation (IV-D-24).

Table 2-5. ANNUALIZED MODEL UNIT CONTROL COSTS AND SAVINGS[a] OF THE BENZENE FUGITIVE EMISSIONS STANDARD[b]
(Thousand May 1979 Dollars)

	Model Unit[c]					
	A		B		C	
Item	New	Existing	New	Existing	New	Existing
Installed Capital Cost	16	17	31	32	48	49
Total Annualized Cost	10.1	10.2	20.1	20.2	30.1	30.4
Recovery Credit	6.9	6.9	20.5	20.5	33.8	33.8
Net Annualized Cost or Savings[d]	3.2	3.3	(0.40)[d]	(0.30)[d]	(3.7)[d]	(3.4)[d]
VOC/Yr Emission Reduction	19 Mg	19 Mg	56 Mg	56 Mg	93 Mg	93 Mg
Benzene/Yr Emission Reduction	12 Mg	12 Mg	31 Mg	31 Mg	71 Mg	71 Mg
Cost (Savings) per Mg Total Emissions Reduced[e]	0.17	0.17	(0.007)[d]	(0.005)[d]	(0.040)[d]	(0.036)[d]
Cost (Savings) per Mg Benzene Reduced	0.27	0.28	(0.013)[d]	(0.010)[d]	(0.052)[d]	(0.048)[d]

[a] Costs are for new and existing units and include monitoring instruments but do not include cost for compressors because compressors in benzene service are not known to exist. Recovery credits are based on total emission reductions (benzene and other VOC) and $370/Mg.

[b] The standard requires monthly leak detection and repair programs for valves and pumps, and equipment specifications for pressure relief devices, open-ended lines, sampling connections, and product accumulator vessels.

[c] Model units have the following numbers of components:

	Model Unit		
	A	B	C
Pumps	5	15	25
Valves			
Gas	34	100	167
Light Liquid	87	264	439
Pressure Relief Devices (gas)	3	9	16
Open-ended Lines	35	105	175
Sampling Connections	9	26	44
Accumulator Vessels	1	2	2

Several assumptions are made to compute model unit costs. For pressure relief devices 75 percent are assumed already controlled in the absence of the standard. For the 25 percent of pressure relief devices that are uncontrolled, it is assumed that 75 percent will be controlled with a closed vent system to flare and 25 percent will be controlled with a rupture disk system. For relief valves using rupture disks, one-half will be controlled with block valves and one-half will be controlled with 3-way valves. For accumulator vessels, 95 percent are assumed already controlled in the absence of the standard.

[d] Numbers in parenthesis denote savings.

[e] Total emissions include benzene and other VOC.

Table 2-6. 1985 NATIONWIDE COSTS OF THE BENZENE FUGITIVE EMISSION STANDARD
(Thousands May 1979 Dollars)

Item	New Units[a]	Existing Units[b]
Installed Capital Cost	1,400	5,500
Total Annualized Cost	900	3,400
Recovery Credit[c]	800	3,000
Net Annualized Cost	100	400
Total Emission Reduction Per Yr	2,200 Mg	8,400 Mg
Benzene Emission Reduction Per Yr	1,500 Mg	5,200 Mg
Cost Per Mg Total Emissions Reduced	0.045	0.048
Cost Per Mg Benzene Reduced	0.067	0.077

[a] New unit construction through 1985 is assumed to be: A, 42; B, 7; and C, 11.

[b] Existing units assumed for 1985 are: A, 131; B, 75; and C, 18.

[c] Based on total (benzene and other VOC) emission reduction and $370/Mg.

Response: The "benzene standards" to which the commenter refers are the regulations for benzene storage vessels, ethylbenzene/styrene plants, maleic anhydride plants, and benzene fugitive emissions. This document only covers benzene fugitive emissions; other documents cover the other source categories.

As discussed in Section 2.1.2, EPA has determined that benzene fugitive emission sources pose significant risk to the public residing in the vicinity of benzene-producing and using plants. The final standard will reduce total benzene fugitive emissions from existing units by about 69 percent at a small industry-wide net annualized cost of $77/Mg of benzene emission reduction. For new units in 1985, the standard will also reduce emissions by about 72 percent at a net cost of $67/Mg of benzene emission reduction. (This is based on not counting the likely effects of standards of performance for VOC fugitive emissions in the synthetic organic chemical manufacturing and petroleum refining industries. To the extent that these standards impact benzene sources, the emission reduction and costs will be proportionately smaller; however, the cost effectiveness will remain the same.) EPA does not consider these cost-effectiveness numbers to be unreasonable.

Comment: One commenter noted that, utilizing the costs presented in the BID for the proposed standard, the cost of saving one life in 20 years will be $116 million. The commenter felt that this is far greater than is considered reasonable in conventional risk/benefit terms. The commenter noted that the Congress, in its actions to minimize auto-related deaths, has established a cost/benefit relationship of $0.5 million to $1.25 million per life saved as being reasonable to the benefit derived (IV-D-24).

Response: The estimated cost of saving one life in 20 years presented by the commenter is based on costs for the standard at proposal. In addition, EPA believes that the commenter's estimate is high. The commenter did not present his method for deriving his estimate. Since proposal, the annualized cost of the standard is estimated to be small. (See Tables 2-5 and 2-6, above.) Imposition of this standard will reduce the incidence of cancer and the exposure of people to benzene with essentially no economic impact on the plants covered by the standard. Therefore, EPA considers the benzene fugitive emissions standard to be reasonable.

Selection of the proposed and promulgated standards was based on emission reductions and costs and consideration of health impacts, not on the dollars spent per life saved. Even though the commenter's "cost-effectiveness" numbers may be calculated correctly, they are not a valid indicator of the benefits derived from the standard. The health impacts considered during selection of the standard are used, not in absolute terms but in relative terms, only in comparing BAT with a more stringent alternative to determine whether or not the residual risks after BAT are unreasonable. A more meaningful and accurate measure of "cost effectiveness" is the cost per unit emission reduction, which in this case is less than $100/Mg of benzene and VOC.

2.6.3 Benefit-Cost Considerations

Most comments on benefit-cost considerations cited Executive Order 12291; these comments implied that the benefits of the standard do not justify the costs. "Benefits" is a much broader term than "effectiveness" and relates to the broad spectrum of improvements that flows from a reduction of emissions.

Comment: Five commenters stated that the Agency has failed to perform an adequate cost-benefit analysis as required by Executive Order 12291 (IV-D-8; IV-D-27; IV-D-19; IV-K-1; IV-F-1). One commenter stated that the proposed standard represents overkill, since the improved air quality achieved by regulating the sources is not fully justified by any benefits shown in the proposed standard. The commenter recommended that EPA reconsider the cost versus benefits of the proposed regulation (IV-D-10).

Response: Executive Order 12291 specifies that a regulatory action, to the extent permitted by law, must not be undertaken unless the potential benefits to society from the regulation outweigh the potential costs to society. An exhaustive benefit-cost analysis is not required here because the benzene fugitive emissions standard does not constitute a major rule within the meaning of the Executive Order and is not appropriate here because the costs and time required to conduct such an analysis are prohibitive.

As discussed in Section 2.6.2, costs per megagram of emission reduction were used in selecting the promulgated standard. This regulation was submitted to the Office of Management and Budget (OMB) for review as required by Executive Order 12291. Any comments from OMB to EPA and any EPA responses to those comments are available for public inspection in Docket No. A-79-27, Central Docket Section, West Tower Lobby, Gallery 1, Waterside Mall, 401 M Street, S.W., Washington, D.C. 20460.

According to the directives of Executive Order 12291, "major rules" are those that are projected to have any of the following impacts:

- An annual effect on the economy of $100 million or more,
- A major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions, or
- Significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets.

As noted above in Tables 2-5 and 2-6, the standard will result in a small net annualized cost. None of the other effects referred to in the Executive Order is anticipated. Thus, the standard does not constitute a major rule because the costs of the standard and its overall impact on the economy will be negligible.

Although benefits have not been rigorously defined and weighed against costs, the standard will create significant benefits. Such benefits are related to the reduction of risks of contracting leukemia due to exposure to benzene.

In addition to the avoidance of the health effects noted above, regulatory action will reduce the rate of emission of VOC's to the atmosphere. Because VOC's are precursors of photochemical oxidants, the ambient concentrations of such oxidants will be reduced. Among the benefits of reduced exposure to ozone are reductions in the following:

- Human health effects - ozone exposure has been shown to cause increased rates of respiratory symptoms, such as coughing, wheezing, sneezing, and shortness of breath; increased rates of headache, eye irritation, and throat irritation; and physiological damage to red blood cells. One experiment links ozone exposure to human cell damages known as chromosomal aberrations.
- Vegetation effects - reduced crop yields as a result of damages to leaves and/or plants have been shown for several crops including citrus, grapes, and cotton. The reduction in crop yields was shown to be linked to the level and duration of ozone exposure.
- Materials effects - ozone exposure has been shown to accelerate the deterioration of organic materials, such as plastics and rubber (elastomers), textile dyes, fibers, and certain paints and coatings.
- Ecosystem effects - continued ozone exposure has been shown to be linked to structural changes of forests, such as the disappearance of certain tree species (Ponderosa and Jeffrey pines) and death of predominant vegetation. Hence, ozone causes a stress to the ecosystem.

2.7 TEST METHODS AND PROCEDURES

Comment: One of the commenters stated that the test method for determining compliance with the 200 ppmv and 10,000 ppmv leak levels is a general hydrocarbon analysis, and, therefore, nonbenzene hydrocarbons are not distinguished from benzene in the analysis. The commenter believed that this test method would require a facility with a stream containing 10.5 percent benzene by weight to control leaks to the same degree as a stream that handles 100 percent benzene and whose fugitive benzene emissions are about 10 times as concentrated (IV-D-20).

Response: The commenter is referring to Reference Method 21. As noted below, Reference Method 21 is used to classify fugitive emission sources according to whether they leak or not. Thus, the method is used to determine which sources of benzene are leaking benzene to the atmosphere, not to determine how much benzene is being leaked. The commenter is correct by stating that different streams containing different percentages of benzene would be required to control leaks to the same degree. However, EPA did not estimate emission reductions and cost effectiveness based on streams containing 100 percent benzene in the line. The estimates were based on estimates of streams in benzene-using and producing plants. These percentages ranged from small amounts (about 25 percent) to large amounts (100 percent). The selection of 10 percent as a cutoff for "in benzene service" addresses the situation of controlling very small amounts of benzene and was discussed in the preamble to the proposed standard. Also, to the extent that a stream with less than an average percent benzene in it is controlled by the standard, the VOC's reduced would be an added benefit (see Section 2.3).

Comment: One commenter remarked that Reference Method 21 cannot be used to calibrate all the instruments allowed by the procedure (IV-D-24). The commenter referred to its March 18, 1981, comments on the SOCMI VOC fugitives CTG. The commenter said that the method allows the use of photoionization devices which will not respond to the calibration gases specified in the method. The commenter recommended that, if an instrument cannot be calibrated, it should not be used to measure emissions.

Response: The reference method has been written to be applied to fugitive emission source screening in general, with specific application requirements being established in each regulation. The method stipulates that the monitoring instrumentation selected by the owner or operator must be responsive to the chemical in the process line, in this case, benzene. The method states that photoionization instruments might meet the requirements, but it does not state categorically that photoionization instruments may be used. However, since this type of analyzer may be useful in certain process units, and it does not respond to methane, an alternative calibration material has been added in the regulation. Based on the comparison of results in the response to the next comment, hexane is specified as the alternate material. At an ionization potential of 11.7-11.8eV, photoionization analyzers will respond to hexane as a calibration material. The use of the alternative material is not limited to a single type of analyzer.

Comment: One commenter noted that EPA's monitoring procedure allows the use of alternate instrumentation that will yield different results for the same leak. This inconsistency, the commenter noted, will lead to enforcement problems. The commenter recommended that the leak rate be defined in terms that will provide consistent monitoring results regardless of the application or analytical instrument operator (IV-D-24).

Response: Reference Method 21 gives specifications for the instrument to be used in monitoring fugitive emission sources of organic compounds. The technique is intended to identify leaks only, not to provide a rigorous analytical concentration of organic compounds. A specific statement has, therefore, been added to Reference Method 21 to clarify the intention to identify leaks only.

The variation in response factor, due to compound or instrument, is not expected to affect significantly the number of leaks determined through screening because screening values are usually much greater than 10,000 ppm for leaks and much less than 10,000 ppm for nonleaks. As demonstrated by the Maintenance Study (IV-A-6, Appendix E), results on valves, the largest percentage of valves found leaking were screened at or above 50,000 ppm. This trend was also noted in the petroleum refining studies (II-A-30). Thus, when a source is found to be leaking, it is likely to have a high screening value.

Laboratory experiments using two organic compound analyzers indicated a wide variation in response factors for a number of organic chemicals from 0 to 571. However, 90 percent of the chemicals tested had responses between 0.1 and 10 (Response Factors of VOC Analyzers, Report No. 4, IV-A-15; Response of Portable VOC Analyzers, Report No. 5, IV-A-19). Differences were also seen between the two types of analyzers tested. When considered in analyzing leak frequencies (Analysis Report, IV-A-18), the response factor variation, however, did not produce significant changes in the percent leaking estimates resulting from the SOCMI 24-unit study (II-A-34). Although a small reduction in the estimated leak frequencies is indicated for gas valves in high leak process units, the estimates in all other cases were almost indistinguishable from the unadjusted estimate. Furthermore, the differences when present were in the same range as the variation in reproducibility described in Docket No. A-79-27-IV-A-6.

Comment: One commenter believed that the portable detectors required in the leak detection program may be impractical due to their inaccuracy, calibration difficulties, and frequent maintenance and replacement (IV-D-16).

Response: The data presented in the EPA report, "Frequency of Leak Occurrence for Fittings in Synthetic Organic Chemical Process Plant Units" (II-A-34), indicated that from 1 to 1-1/2 hours per day were required for calibration and maintenance of the monitoring instrument. Based on the number of sources that were screened in each unit, this calibration time amounted to 16 to 25 percent of the total time for screening.

The calibration time during the EPA studies was expected to be longer than for screening alone since concentration measurements were being recorded that would be used in further analysis. This necessitated calibration with more than one standard concentration on a more frequent basis (2 to 3 times daily). Also, because concentrations up to 100,000 ppm were being measured, a dilution probe had to be calibrated several times daily. However, routine screening would require calibration with only one standard concentration. Also, a dilution probe would not be required. Calibration time for routine screening is estimated to require about 10 to 25 percent of that required during EPA tests, or about 2 to 6 percent of the total time for screening.

The SOCMI 24-unit study report also listed a number of problems, equipment-related and procedure-related, that were encountered during the study. Procedure-related problems, as well as equipment problems, to a large extent were due to the contractor's being remotely located from his laboratories and repair facilities. Problems with instruments in the field take longer to fix because of shipping delays. Furthermore, many inefficiencies were encountered because the personnel performing the studies were research staff who spent only short periods of time on projects of this type, thereby lacking the experience necessary for troubleshooting.

Time lost due to equipment failure is expected to be minimized by maintaining the critical spare instrument parts (including readout meter, battery pack, regulator repair kit, pressure gauges, hydrogen flow valves, and filters) identified during the 24-unit study. Additionally, personnel familiar with the troubleshooting procedures should facilitate instrument operation and repair. The proximity of instrument shops and labs within plants affected by the standard should also improve routine screening efficiency.

The cost estimates in the BID for the proposed standard include costs for two instruments, one of which was considered a spare. Having a spare should decrease instrument downtime. Moreover, an ample allowance of time was made for calibration and maintenance of instruments. The 40 percent administrative and overhead charge allotted includes time for calibration, and an additional $2,700 per year was allotted for instrument materials and maintenance. In view of these differences between research field studies and routine screening activities, the calibration and maintenance costs allotted in the BID for the proposed standard are reasonable, and no adjustments have been made.

Comment: One commenter suggested that EPA determine whether a sufficient supply of detectors is available (IV-D-16).

Response: EPA has no reason to believe that there is not a sufficient supply of detectors available. Detectors such as those allowed by the standard have been in use since promulgation of State and OSHA regulations.

2.8 GENERAL ISSUES

2.8.1 Applicability

Several commenters questioned the applicability of specific requirements on certain sources and facilities.

2.8.1.1 Exemption Requests. Five commenters requested exemption from the standard for various facilities or sources.

Comment: One of these commenters recommended that certain small-volume or intermittent benzene uses, such as use in pharmaceutical production, be exempted from the standard (IV-D-16). The commenter stated that in a pharmaceutical plant much of the process equipment is multipurpose and is used for batch operations, rather than continuous processes characteristic of large-scale organic chemical plants and petroleum refineries. The variability in process operations and in raw material usage would make it difficult to implement the leak detection program as required by the standard. The commenter noted that pharmaceutical plants contain facilities incorporating extensive small-volume pipeline systems, where a single processing train could contain several hundred potential fugitive emission sources subject to the standard. The commenter also stated that, in general, the volume of benzene handled by pharmaceutical process equipment in continuous operation is small compared to large volumes of benzene handled in a benzene production unit. The commenter believed that since benzene emissions from their batch processes are small, the risk of benzene exposure to public health is small. The commenter stated that small volume users and users other than organic chemical plants were not considered in EPA's evaluation of the economic and environmental impact of the standard.

Response: The intent of the standard is to reduce benzene emissions from fugitive emission sources that contact benzene. Although some processes are batch or intermittent, they can emit benzene in significant quantities because these processes may require many pieces of equipment with potential to emit benzene. However, EPA believes it is reasonable to exempt plants from the standard when the cost of the standard is unreasonably high in comparison to the achieved emission reductions. Therefore, EPA decided to determine a cutoff for exempting these plants based on a cost and emission reduction analysis.

Two approaches for setting the cutoff were considered: (1) number of sources at a plant site and (2) benzene usage per plant site. A cutoff based on the number of sources at a plant site would be consistent with the model units used as a basis for the impacts of the standard. However, this cutoff could not be applied readily to small or intermittent users of benzene, such as pharmaceutical manufacturers and research and development facilities. These facilities often require frequent repiping; therefore, it is difficult to keep track of how many sources are located at a plant site.

A cutoff based on benzene design usage is reasonable because it is easily understood and can be applied readily to a plant site. However, it is inconsistent with the model unit development where throughput and emissions are generally not related, and its determination is less straightforward than basing the cutoff on number of sources. However, because the design capacity of a plant using or producing benzene can be applied easily, it was chosen as the basis for the cutoff.

For plants in which the benzene emission reduction achieved by implementing the standard is about 4 Mg of benzene per year, EPA has determined that the cost of achieving this emission reduction is unreasonable. In order to exclude plants on this basis, EPA selected a minimium cutoff of 1,000 Mg/year per plant site based on a benzene design usage rate or throughput. Throughput is determined by a mass balance during the design stages of process operations, accumulating all benzene processed in 1 year. The derivation of this cutoff is presented in Docket Number IV-B-17. For plants with a benzene design usage rate greater than 1,000 Mg/year, the cost of the standard is reasonable.

Comment: Another commenter suggested that the applicability of the proposed rule be defined specifically to exclude research and development activities and pilot plant studies which are already designed to limit worker exposure to benzene (IV-D-26). One commenter suggested an 18-month exemption for small temporary sources that would allow laboratory, developmental pilot plant work, and full scale experimental runs or commercial tests without the control and monitoring requirements (IV-D-29).

Response: The commenter suggests an exemption for small temporary sources, such as laboratories and developmental pilot plants. Even though worker exposure to benzene in these operations already may be limited, the OSHA standards are not applicable in regulating benzene fugitive emissions to atmosphere as discussed in the response to the first comment in Section 2.1.2. As indicated in the previous response, a plant design usage or throughput rate of benzene equal to or less than 1,000 Mg/yr per plant has been selected as a cutoff. Based on the minimal amount of benzene processed at laboratory facilities and pilot plants, the 1,000 Mg/yr cutoff is likely to exempt most of these sources from the standard. Large-scale pilot plants or commercial tests might process more than 1,000 Mg/yr. If this happens, these plants would not have difficulty in achieving the standard since there are no major equipment requirements and the work practice requirements are reasonable, considering costs and emission reductions achievable. An 18-month exemption for small temporary sources with a plant design usage rate of benzene greater than 1,000 Mg/yr is not needed because these sources would not experience unreasonable costs and would achieve the same emission reduction as production units.

Comment: One commenter suggested that flanges should be removed from the definition of fugitive emission source, since testing by Radian and others shows that flanges are a negligible source of emissions. The commenter also recommended an exemption for pipeline systems transporting benzene, especially from a plant to a remote terminal or benzene-consuming facility. Due to the remote nature of some stations, the commenter noted that the requirement of weekly visual inspections of pumps and compressors and daily visual inspections required of new pumps and compressors is unduly burdensome to the owner or operator of the pipeline. The commenter added that requiring daily visual inspections for replacement pumps may delay the replacement of existing pumps and may result in increased emissions from the older pumps (IV-D-30).

Response: EPA agrees with the commenter that flanges are a small source of emissions. Flanges in refineries contribute 2.2 percent of all benzene fugitive emissions. However, flanges comprise 61 percent of the total number of benzene fugitive emission sources. Thus, a great deal of effort would be required to control these emissions. For this reason, EPA excluded flanges in benzene service from routine leak detection and equipment requirements in the proposed standard. However, flanges do leak occasionally; therefore, the proposed standard required that, if leaks are detected from flanges, they must be repaired within the same allowable time as other sources (15 days). EPA has not changed this requirement since proposal.

The commenter expressed concern that the pump and compressor requirements are unduly burdensome for remotely located pipeline systems. As discussed in Section 2.3.2, the equipment requirement (dual mechanical seal system) for new pumps has been deleted and replaced with a monthly leak detection and repair program, which is also required for existing pumps. This revision eliminates daily inspection of the sensor (or as an alternate, installation of an audible alarm) to detect failure of the seal system. Weekly visual inspections for liquids dripping from new and existing pump seals are still required except for pumps that are remotely located.

Remotely located emission sources are ones that are not located within the boundary of the plant site. This equipment must be visually inspected as often as practicable and at least monthly.

Compressors are required to be controlled with degassing vent systems. Therefore, daily sensor checks (or installation of an audible alarm) are still required unless the compressor is remotely located. Weekly visual inspections of compressors have never been required.

For remotely located pumps and compressors, therefore, daily sensor checks (or installation of audible alarm) and weekly visual inspections of leaking equipment are not required, although they should be inspected as often as practicable. However, the monthly leak detection and repair requirements do apply to these remotely located components except compressors. Compressors must use seal systems; therefore, leak detection requirements are not needed.

Comment: One commenter expressed concern that EPA did not consider equipment size or accessibility in its monitoring requirements for pumps, compressors, valves, flanges, and pressure relief devices. According to the commenter, the standard would apply to all equipment in benzene service whether it is 1/8-inch tubing or a 48-inch pipe. The commenter suggested, therefore, that the standard apply only to meaningful and accessible sources, i.e., process lines 6-inch pipe size and above (IV-D-29).

Response: EPA did not use equipment size as a criterion of applicability in developing the benzene fugitive emissions standard. Benzene fugitive emissions are not related to size of pipe. Instead, data from an EPA study on fugitive hydrocarbon emissions in petroleum refineries (II-A-30, pages 131-189) indicate that there is generally little or no correlation between line size and leak rate. Furthermore, the data indicate that the majority of valves in gas and light liquid service and flanges have line sizes less than 6 inches. The commenter's suggestion that the standard apply to process lines 6 inches or greater would probably exempt most of the equipment from the standard. An exemption for equipment based on size, therefore, is not justified.

The commenter also suggests that accessibility of equipment should have been considered in developing the standard. Accessibility of valves is discussed in Section 2.4.2.1.

Comment: One commenter suggested that provisions be added to the definition of modification for exempting de minimis levels and for reconstruction that yields no net increase in emissions (IV-D-21). The commenter referred to comments on the SOCMI VOC fugitives NSPS (A-79-32-IV-D-17).

Response: The commenter's suggestion that de minimis levels of benzene be exempted under the modifications provisions does not consider what is actually being covered by the standard. The commenter appears to think that each process unit is the basis for coverage under the standard. Actually, the designated source for the standard is each fugitive emission source (e.g., pump or valve) in benzene service. Therefore, there would be no modifications because each source, whether it is new or existing, would have the same emission rate. No provision to exempt de minimis levels of benzene is necessary. The reconstruction provisions of the regulation have been deleted since proposal. Thus, the comment on reconstruction needs no specific response. However, more importantly, the standard does differ for new and existing sources.

2.8.1.2 Ten Percent Benzene Cutoff. Several commenters questioned the applicability of sources based on the 10 percent cutoff concentration of benzene.

Comment: Two commenters stated the 10 percent cutoff would exclude benzene emissions from gasoline stations (IV-D-29) and motor fuel evaporation, containing about 4 percent benzene (IV-D-2). Another commenter noted the existence in Buffalo, New York, of a refinery which has no process streams containing greater than 10 percent benzene (IV-D-10). One commenter recommended that EPA make provision for the possibility of plant designers' diluting certain streams to avoid the need for controls. The commenter added that where streams fluctuate above and below 10 percent benzene, EPA should make clear that the whole stream and its associated valves, seals, and pumps are subject to the standard (IV-D-31).

Response: The selection of the 10 percent cutoff concentration of benzene was based on estimates indicating that 90 percent or more of the total benzene fugitive emissions originate from components that process materials containing 10 or more percent by weight benzene. The 10 percent cutoff was proposed to be used to distinguish between process streams where benzene can be expected and those streams where benzene might not be expected, where the quantity of benzene is relatively minor, or where benzene is incidental. EPA proposed to exclude from coverage those sources that handle streams below 10 percent by weight benzene based on the relatively small amount of benzene contained by these sources and the large number of sources with streams below the cutoff. If a refinery or chemical plant, such as the one mentioned by the commenter (IV-D-10), does not have any process streams containing greater than 10 percent benzene, then fugitive emission sources in that plant are not covered by the standard. As mentioned in the preamble to the proposed standard, the 10 percent cutoff could be revised if data become available that indicate emissions are higher than are currently estimated for streams below the cutoff. Commenters presented no data on this decision and, therefore, no change was made to the 10 percent cutoff.

In surveying all possible sources of benzene fugitive emissions, a cutoff was deemed necessary to avoid covering a large number or relatively minor sources of benzene. A zero percent cutoff would cover sources containing any amount of benzene. A 1 percent cutoff would exclude both crude oil and refinery streams containing trace amounts of benzene. Benzene concentrations between 1 and 10 percent are found in gasoline and gasoline blending components. These streams were exempted because of the large number of sources within this range and the relatively small amount of benzene emissions. The 10 percent cutoff also excludes chemical streams where benzene is a contaminant.

One commenter (IV-D-31) suggested the possibility that plant designers might dilute certain streams to avoid meeting the 10 percent cutoff and, thus, avoid the need for controls. The likelihood of a plant using this tactic to avoid coverage under the standard is minimal. Diluting a process stream would not be a cost-effective practice for industry, since in the end it would take more energy or benzene to produce an intermediate or final product. Because the costs of this standard are so small, dilution would likely cost the operator more than the cost of compliance with the standard. Also, the commenter noted that streams sometimes fluctuate. The standard covers stream that are intended to be greater than 10 percent. If a stream can reasonably be expected to fluctuate above 10 percent, it is already covered by the standard. The need for a special provision in the standard to avoid these situations, therefore, is unwarranted.

2.8.2 Selection of Baseline

Comment: One commenter questioned EPA's baseline for calculating incremental benefits of control alternatives. The commenter stated that Regulatory Alternative II should be used as a baseline in nonattainment areas instead of Regulatory Alternative I, since Alternative II is based on CTG controls already being implemented in refineries through SIP's. The commenter further recommended that emission reduction and cost estimates be recalculated on the basis of CTG controls prescribed by Regulatory Alternative II (IV-D-13; IV-D-27).

Response: At proposal, EPA estimated that uncontrolled benzene fugitive emissions were about 8,300 megagrams per year for existing units and about 2,500 megagrams per year for new units by 1985. This estimate did not include the effects of the CTG for petroleum refineries. Since proposal, these effects have been included in the estimated impacts of the standard. Baseline emissions are defined on two levels: on an industry-wide basis and on a process unit basis. An industry-wide baseline, which depicts expected emissions given current regulations, is used in evaluating whether or not to regulate emissions from the subject source category. The industry-wide baseline for fugitive emissions of benzene represents the sum of uncontrolled emissions from chemical and pharmaceutical plants, uncontrolled emissions from petroleum refineries in National Ambient Air Quality Standard (NAAQS) attainment areas for ozone, and SIP controlled emissions from petroleum refineries in NAAQS nonattainment areas for ozone. Uncontrolled fugitive benzene emission estimates for petroleum refineries in NAAQS nonattainment areas are reduced, as requested by the commenter, by implementing controls specified in the petroleum refinery VOC control techniques guideline (CTG) document (II-A-10). Thus, industry-wide baseline emissions of benzene, which have been re-estimated to be about 7,920 megagrams per year for existing units and about 2,470 megagrams per year for new units by 1985 correctly account for the contribution of fugitive emissions of benzene from uncontrolled chemical plants and refineries and from refineries operating using CTG controls (IV-B-11).

Baseline emissions also are defined on a process unit basis in order to compare the overall effectiveness of each alternative control technique in reducing emissions from the least restrictive control level used on any process unit. Most process units are not required to use CTG controls because many process units are located in NAAQS attainment areas for ozone. Thus, process unit baseline emissions represent uncontrolled emissions (the least restrictive control level used on any process unit) and correctly do not include emissions that occur while using CTG controls. However, as requested by the commenter, emission reductions using CTG controls was one of the control options considered for the final standard. More importantly, because EPA has used incremental costs and emission reductions in selecting the basis of the final standard (which has changed since proposal), the baseline does not affect selection of the level of the standard.

2.8.3 Format of the Standard

Comment: Several commenters criticized the basic format of the standard, recommending that the regulation should be based on performance criteria or an acceptable ambient exposure level rather than a specification standard or work procedure standard. One commenter noted that a performance-based standard would allow more flexibility and would be compatible with existing OSHA rules for benzene. The commenter suggested that EPA should be willing to accept compliance to a limit of detection OSHA criterion (e.g., 1 ppmv) as compliance with the benzene fugitive emissions standard, since OSHA is still considering possible revision to the benzene workplace standard (IV-D-24). Two of the commenters stated that industry should select its own control method as long as it meets a performance limit. The commenters recommended that an emission level (acceptable leak rate) be prescribed for all pumps and compressors (new and existing) instead of equipment specifications (IV-D-13; IV-D-24; IV-D-27). Another commenter stated that a work procedure standard is easiest to enforce, but is rigid and requires special paper work that would be excessively burdensome to industry. According to the commenter, a performance standard would allow each individual source to adopt the most cost-effective methods for benzene control (IV-D-29). This commenter also recommended that EPA establish an "acceptable ambient exposure level" for benzene and then allow each individual source to develop a program to limit exposures of individuals living around the plant site (IV-D-29).

Response: As discussed in the preamble to the proposed standard, Section 112(e) of the Clean Air Act requires that an emission (performance) standard be established for control of a hazardous air pollutant unless it is not feasible to prescribe or enforce such a standard. A performance standard is not feasible in the following circumstances: (1) if the pollutant can not be emitted through a conveyance designed and constructed to emit or capture the pollutant or (2) if the application of measurement methodology is not practicable due to technological or economic limitations. If either or both of these circumstances exist, then the Clean Air Act gives EPA the authority to require a design, equipment, work practice, or operational standard, or a combination.

EPA agrees with the commenters that a performance standard does allow more flexibility in complying with the standard than the other regulatory formats. However, EPA has found that a performance standard is only feasible for leakless equipment and pressure relief devices. A control technique is available that eliminates fugitive emissions from pressure relief devices, and Reference Method 21 can be used to detect leaks of fugitive emissions from pressure relief devices. In general, a performance standard is not feasibile for other fugitive emission sources because the application of available measurement methods is not practicable due to technological or economic limitations. For example, valves, pumps, and sampling systems generally are not designed to release fugitive emissions into a conveyance. Furthermore, measurement of an emission level for the number of valves, pumps, and compressors by the bagging method would be expensive, time-consuming, and impractical. However, for valves, pumps, and compressors that can achieve a no detectable emission limit, a performance standard is provided because it is equivalent to BAT for these sources.

EPA is allowing two alternative standards for valves in a process unit. As discussed in Section 2.4.2.11, these alternative standards will limit the maximum percent of valves leaking within a process unit to 2 percent. This will give plant owners and operators more flexibility in complying with the standard for valves because it allows for the possibility of different leak detection and repair programs and substitution of engineering controls. This flexibility is not available for other fugitive emission sources, however, because there are not enough of these other sources to base the alternative standards on statistical procedures.

Section 112 of the Clean Air Act requires an emission standard, not an ambient air quality standard. Furthermore, it is not possible to set an "acceptable, ambient exposure level," as recommended by the commenter. A work practice standard was selected for pumps and valves with a leak definition of 10,000 ppm by volume. This leak definition is a technology-based requirement and not a health-based "exposure level."

Comment: One commenter recommended an approach that evaluates specific areas with known problems and that includes control regulations directed to those areas. For example, SIP's could be used to identify control strategies where problem areas have been documented (IV-D-10).

Response: EPA has examined a variety of existing regulatory programs (including relying solely on State programs) and has concluded that despite existing controls, benzene emissions from fugitive emission sources pose a significant risk to public health. Having reached this decision, EPA lacks authority to promulgate any standards other than a national standard for this source category. Section 112 clearly contemplates that NESHAP's be uniform; Section 112 speaks of promulgating a "standard," which is meant to protect public health. Moreover, Section 112(e)(2)(B) speaks of a "particular class of sources," which suggests that Congress intended standards to be applicable to such a class as a whole. Finally, nothing in Section 112 or its legislative history offers any indication that EPA could promulgate anything other than a uniform national standard.

It should be noted that defining source categories according to the population density around a source would ignore the constant changes in population. Such an approach would be very difficult to implement; it would entail determining a standard for each source. Furthermore, this approach would not consider the risk to the most exposed group of people.

2.8.4 Emissions Data Base

Several commenters questioned the data used to estimate emission rates of benzene from fugitive emission sources.

Comment: Two commenters stated that existing data do not accurately reflect actual benzene emissions from fugitive emission sources. The commenters cited the EPA screening study on 23 SOCMI units as the basis for their concern. One of the commenters felt that until better data are produced, EPA should not continue developing the proposed standard (IV-F-1). The same commenter further stated (in another set of comments) that the BID for the proposed standard overestimates benzene fugitive emissions by 25 to 33 percent (IV-D-21). The other commenter stated that EPA did not base its emissions source data upon fugitive emissions from benzene units only. The commenter indicated that recent studies suggest benzene emissions may be two to three times less than that relied upon by EPA in the proposed benzene regulation (IV-K-1).

Response: The commenters question the basis for the emission factors used by EPA in estimating benzene fugitive emissions. During preparation of the BID for the proposed standard, EPA examined data associated with equipment in benzene units and found the data insufficient for direct estimation of benzene emissions, as discussed below. In the BID for the proposed standard, refinery VOC fugitive emission factors were used to estimate VOC emissions from benzene-service equipment. These VOC emissions were then "corrected" to benzene emissions by multiplying by the average weight percent benzene in the process stream. This procedure is based on the assumption that the ratio of benzene emissions to VOC emissions is the same as the ratio of the amount of benzene to VOC in the process stream.

Since preparation of the BID for the proposed standard, new data have become available, which EPA has considered. Some of the new data are cumene data from the EPA screening studies to which the commenters refer. Other data concern equipment in benzene service within coke oven by-product plants. In addition to these new data, EPA has developed and considered VOC emission factors for benzene-service equipment (IV-B-22) based on an "adjusted" approach as explained in "Fugitive Emission Sources of Organic Compounds--Additional Information on Emissions, Emission Reductions, and Costs" (AID) (IV-A-24).

Available leak frequency data are summarized in Table 2-7, and VOC emission factors are shown in Figures 2-1 through 2-3. As with the data available at proposal, the new data were found to be insufficient for direct estimation of benzene emissions. After analyzing all available data, EPA concluded that the refinery VOC emission factors and the concentration of benzene within the process stream should be used as the basis for emission estimates for fugitive emission sources of benzene. Thus, EPA has not changed the approach used at proposal to estimate benzene emissions from fugitive emission sources, as detailed below. The estimates for benzene emissions from controlled sources have been revised using the LDAR model, which is described in Appendix B.

In the BID for the proposed standard, EPA considered several data sets to estimate benzene emissions. None of the data sets was limited to benzene-service equipment, thus no benzene-specific emission estimates could be developed. However, EPA concluded that VOC emission estimates could be adjusted to estimate benzene emissions from fugitive emission sources. Much of the leak frequency data shown in Table 2-7 was available at proposal; however, the only VOC emission factors available were for refinery equipment. The leak frequency data from the cumene units, Unit E, and Unit F do not appear to be substantially different from the refinery data, especially considering the confidence intervals associated with the data.

Limited testing of the benzene content of process streams and fugitive emissions from these process streams performed during the testing at Units E and F supports the approach of adjusting VOC emission estimates to obtain estimates of benzene emissions (IV-A-2). These data indicate a similarity between the weight fraction benzene in the process stream and the weight fraction benzene in a leak. Because the refinery leak frequency data were not substantially different from the other available leak frequency data that included benzene-service equipment, and because the refinery emission factors were the only comprehensive set of emission factors available that included benzene-service equipment, the refinery emission factors were used to estimate VOC emissions from benzene-service equipment. These estimates were then used to quantify benzene emissions by correcting the VOC emission estimates based on the percent benzene in the process stream.

Table 2-7. COMPARISON OF LEAK FREQUENCIES FOR VALVES AND PUMPS

	VALVES						PUMPS		
	GAS SERVICE			LIGHT LIQUID SERVICE			LIGHT LIQUID SERVICE		
Study	Number Tested	Percent Leaking^{a}	95% CI^{b}	Number Tested	Percent Leaking^{a}	95% CI^{b}	Number Tested	Percent Leaking^{a}	95% CI^{b}
Refinery^{c,m}	563	10	6-14	913	11.0	8-14	470	24	19-26
SOCMI^{d,m}	9669	11.4	10.8-12.0	18,299	6.5	6.1-6.9	646	8.8	6.4-11
Benzene Equipment^{d,e}	332	16	12-20^{f}	536	9.1	6.6-11.6	12^{g}	25^{g} (50)^{g}	0-50^{f} (9-91)^{f}
Coke oven by-product^{n}	--^{o}	--^{o}	--^{o}	135	5.9	1.8-10	20	45	23-67^{f}
Cumene^{h,i,m}	448	14.1	11.1-17.8	799	10.5	8.5-12.8	25	16	4.5-36.1
BTX^{j,h}	18	5.6	1-35	24	4.2	0-21	38	15.8	6-31
HDA^{j,h}	6	16.7	0-64	24	0.0	0-14	5	40	5-85
Unit E (BTX)^{h,k,m}	--^{o}	--^{o}	--^{o}	715^{l}	1.1^{l}	0.3-1.9	33	3.0	0-8.9^{f}
Unit F (HDA)^{h,k,m}	--^{o}	--^{o}	--^{o}	427^{l}	7.0^{l}	4.5-9.5	30	10	0-21^{f}

Table 2-7. COMPARISON OF LEAK FREQUENCIES FOR VALVES AND PUMPS (concluded)

Footnotes:

[a] Percent with screening values greater than or equal to 10,000 ppmv.

[b] 95 percent confidence interval for percent leaking greater than or equal to 10,000 ppmv.

[c] Screened with Bacharach TLV Sniffer calibrated with hexane. Reference: Wetherold, R.G., et al. Assessment of Atmospheric Emissions from Petroleum Refining. Volume 3, Appendix B. Prepared for U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory. Research Triangle Park, N.C. Report Number EPA-600/2-80-075c. April 1980. p. 84-124. Docket Number II-A-30.

[d] Screened with OVA-108 calibrated with methane. Reference: Langley, et al. Analysis of SOCMI VOC Fugitive Emissions Data. Prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Report Number EPA-600/2-81-111. June 1981. p. 23-24. Docket Number IV-A-18.

[e] Benzene equipment only; benzene is reported as primary or secondary chemical in the "Analysis" report (footnote d). These data are mainly from cumene units.

[f] 95 percent confidence intervals estimated as two standard deviations.

[g] One-half of these pumps were equipped with single seals, and one-half were equipped with double seals with heavy liquid barrier fluid. Of the single seals, 50 percent were found leaking.

[h] All equipment in the unit; not limited to benzene service.

[i] Screened with OVA-108 calibrated with methane; these data are a subset of SOCMI data (footnote d). Reference: Blacksmith, et al. Frequency of Leak Occurrence for Fittings in Synthetic Organic Chemical Plant Process Units. Prepared for U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. Report Number EPA-600/2-81-003. September 1980. p. 32. Docket Number II-A-34.

[j] Screened with Bacharach TLV Sniffer calibrated with hexane; these data are a subset of the refinery data (footnote c). Reference: Fugitive Emission Sources of Organic Compounds--Additional information on Emissions, Emission Reductions, and Costs (AID), U.S. EPA, Emission Standards and Engineering Division, Research Triangle Park, N.C. April 1982. p. 2-4, 2-7. Docket Number IV-A-24.

[k] Screened with OVA-108 calibrated with methane. Reference: Air Pollution Emission Test - Benzene Fugitive Emissions in Petroleum Refineries (Sun Petroleum Products Company, Toledo, OH., November 3-17, 1978). Prepared by U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Measurement Branch, Research Triangle Park, N.C. Report Number EMB-78-OCM-12B. October 1980. p. 5-6. Docket Number IV-A-2.

[l] Number of valves screened and percent of valves leaking are for gas and light liquid service valves combined. Most valves, however, are in light liquid service.

[m] These data were available before proposal of the benzene fugitive emissions standard.

[n] Screened with OVA-108 and Bacharach TLV Sniffer. Calibration gas was not stated. Reference: Benzene Fugitive Leaks - Coke Oven By-Product Plants: Leak Frequency and Emission Factors for Fittings in Coke Oven By-Product Plants. U.S. EPA, Emission Standards and Engineering Division, Emission Measurement Branch, Research Triangle Park, N.C. Report Number EMB-81-BYC-12. January 1982. p. 7. Docket Number IV-A-23.

[o] Gas valve data included in the light liquid valve totals.

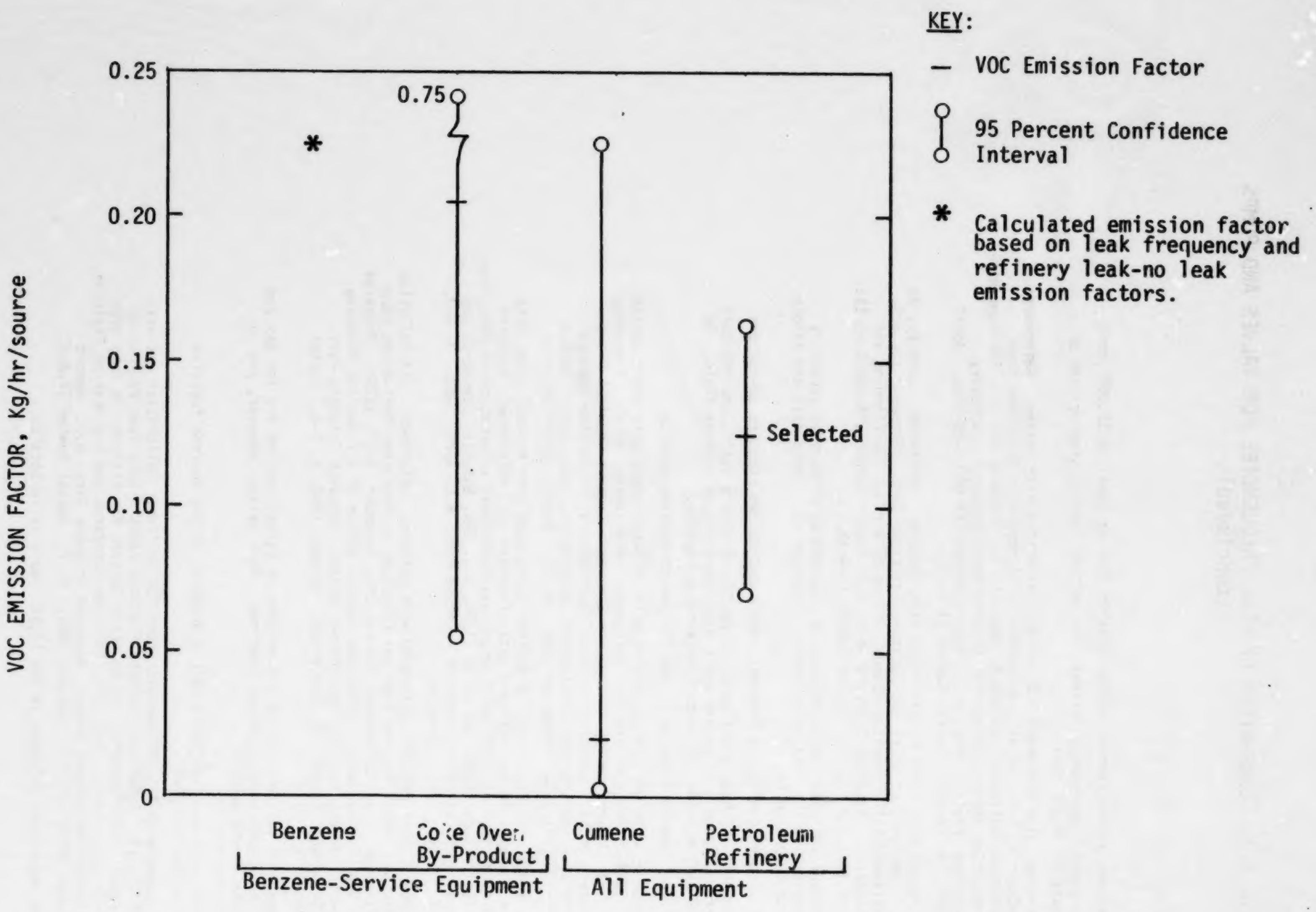


Figure 2-1. Emission factors for light liquid-service pump seals for benzene, coke oven by-product, cumene, and petroleum refinery units.

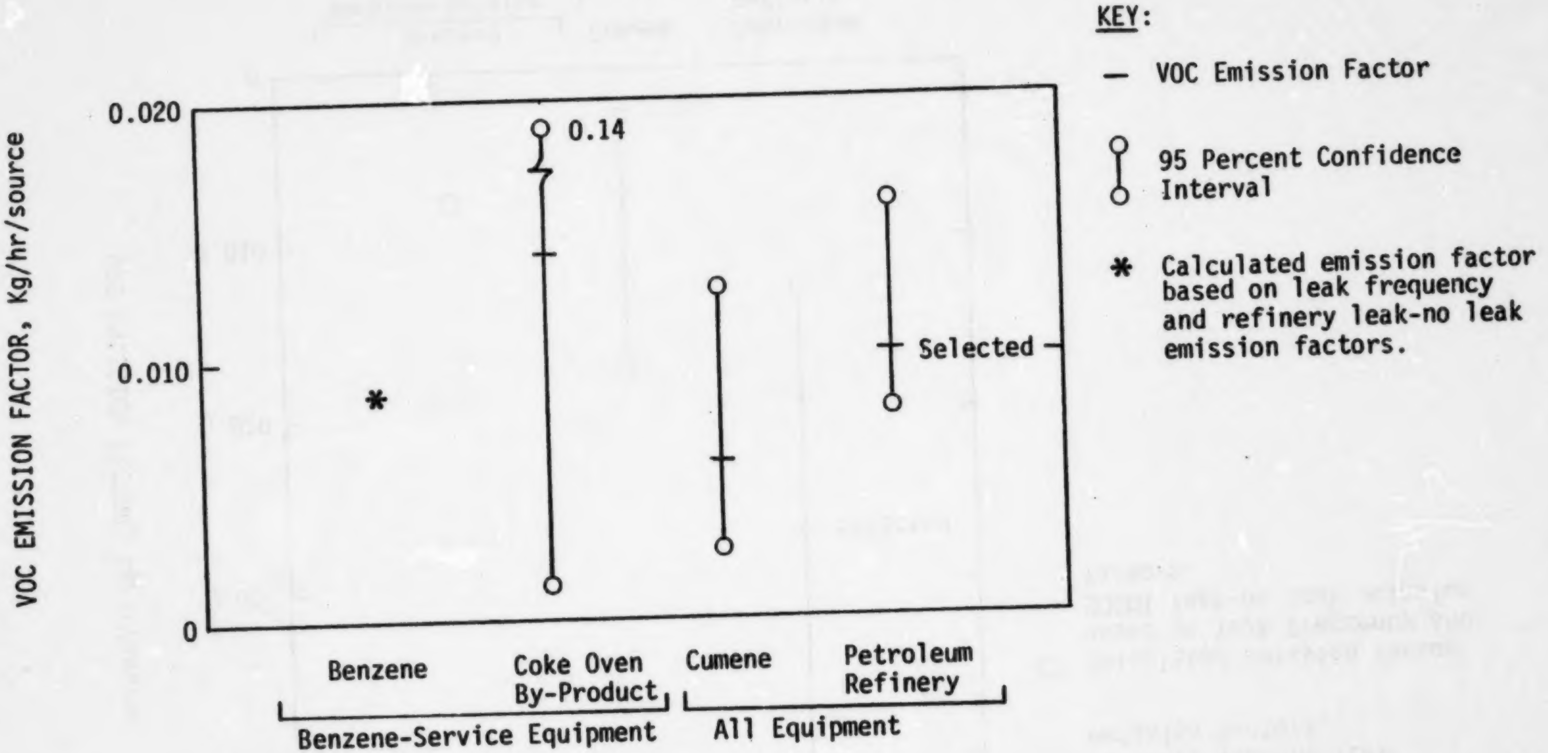


Figure 2-2. Emission factors for light liquid-service valves for benzene, coke oven by-products, cumene, and petroleum refinery units.

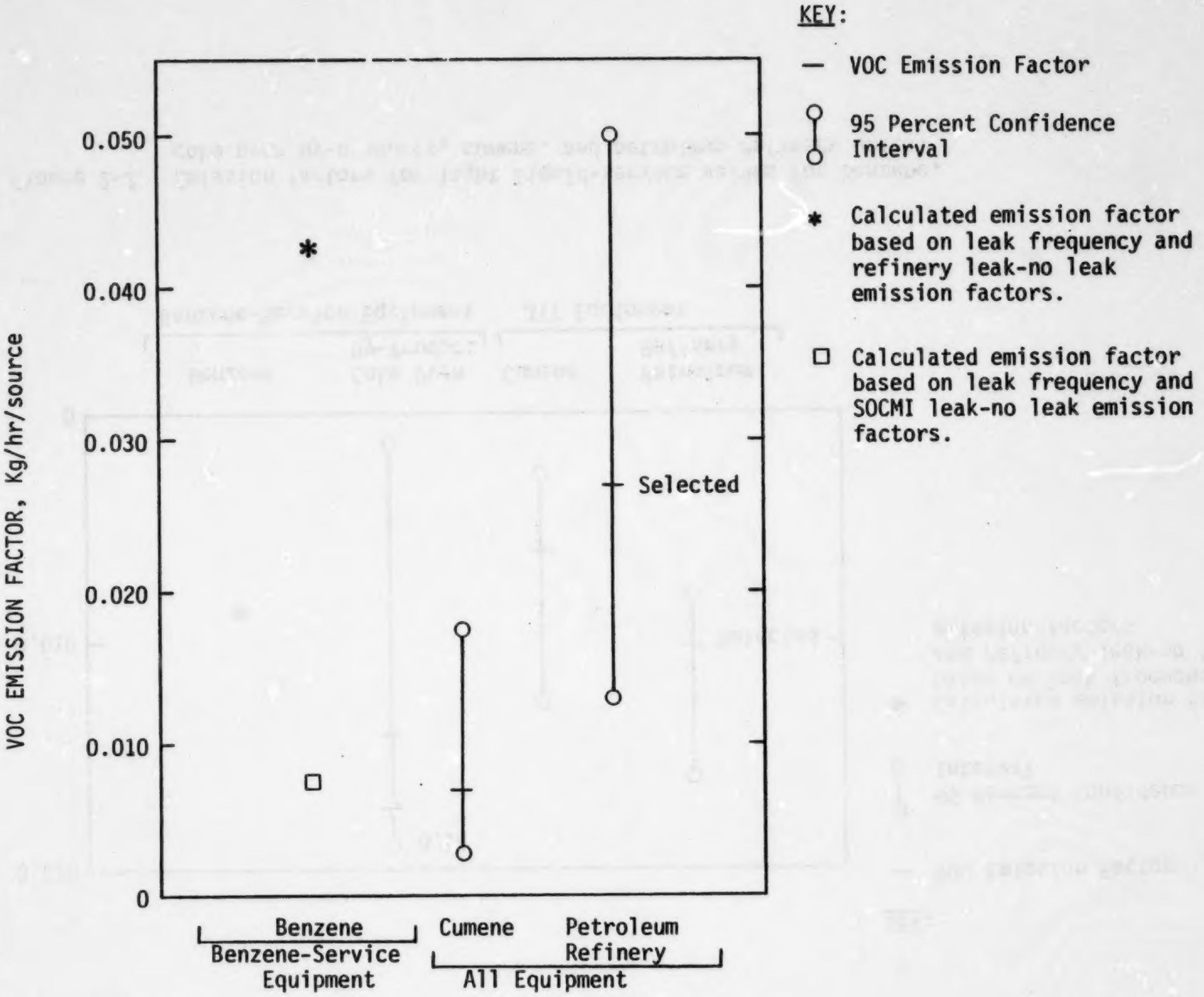


Figure 2-3. Emission factors for gas-service valves for benzene, cumene, and petroleum refinery units.

Since proposal, several additional data sets have been analyzed. These include the leak frequency data shown in Table 2-7 for benzene-service equipment, coke oven by-product plant equipment, and the BTX and HDA unit equipment. In addition, new VOC emission factors have become available for several sources. Figures 2-1 through 2-3 compare recently available VOC emission factors for cumene units, coke oven by-product plants, and benzene-service equipment to the refinery factors.

The benzene-service equipment leak frequency data are from the "Analysis" report (IV-A-18). These data are for equipment in the SOCMI 24-unit study that had benzene as the primary or secondary chemical in the process stream. Most of these data are from cumene units, while the remainder is from ethylene units. The leak frequency for benzene-service gas valves and single-seal light liquid pumps is higher than the corresponding leak frequency for the refining data, and the light liquid valve leak frequency is slightly lower. VOC emission factors were developed for the benzene-service equipment using the technique discussed in the AID as follows (IV-B-22): Emission factors for leaking and nonleaking sources were developed based on the refinery and SOCMI data. These emission factors and the benzene-service equipment leak frequencies were then used to calculate overall VOC emission factors for benzene-service equipment. These emission factors generally fall within the confidence intervals of the other emission factors and (1) are higher than the refinery VOC emission factors for light liquid pumps, (2) are about the same for light liquid valves, and (3) are higher or lower than the valve (gas service) emission factor depending on whether the basis is the refinery or SOCMI estimation, respectively.

Testing was performed at three coke oven by-product plants to develop estimates of fugitive emissions. The coke oven leak frequency data shown in Table 2-7 are for equipment in benzene service. Very few gas-service valves were tested, so these data were combined with the light liquid-service equipment in the data presentation. Table 2-7 shows the light liquid valve leak frequency for coke oven by-product plants is one-half that of the refinery data, while for light liquid pumps the coke oven leak frequency is twice that of the refinery data. VOC emission factors were developed specifically for the coke oven by-product plant benzene-service equipment, and they are shown in

Figures 2-1 through 2-3. Because of the limited amount of data collected in these plants, the confidence intervals for the VOC emission factor estimates are very large. These confidence intervals completely overlap the refinery factor confidence intervals. In addition, the actual estimates are within the confidence intervals of the refinery emission factors for both light liquid pumps and valves. Additional testing was performed at coke oven by-product plants to compare the weight fraction benzene in the process stream to the weight fraction benzene in a leak from that process stream. These data show that the average difference in the benzene fraction was -15 percent; that is, the weight fraction benzene in the leak averaged only 15 percent greater than the weight fraction benzene in the process line. (If the absolute values of the differences between the process stream and leak fraction benzene are used, the average difference is 19 percent). The largest percent differences were found for the sources with the lowest leak rates. These differences are well within the accuracy of the determination of the percent benzene and the emission rate determinations, so they are not significant (IV-B-23).

The BTX and HDA unit leak frequency data shown in Table 2-7 are a subset of the refinery study data (II-A-30). For all sources the confidence intervals for these data overlap, partially due to the limited nature of the benzene testing in the refinery study.

Leak frequency data were available for the cumene units at proposal of the standard. However, since proposal these data have been used along with other data on emission rates from the SOCMI Maintenance study (IV-A-6) to estimate VOC emission factors for cumene units as shown in Figures 2-1 through 2-3. For all three sources, the confidence intervals for the cumene emission factors overlap those of the refinery data, and the estimated VOC emission factors are lower than those of the refinery data.

In selecting the method to determine benzene emissions from benzene-service equipment, all of the preceding data were considered. As at proposal, the only method available to estimate emissions of benzene from fugitive emission sources is the adjustment of VOC emission estimates. Further, since VOC emissions would also be controlled by a benzene standard with the resultant reduction in product loss and VOC emissions to atmosphere, it is desirable to use a technique that quantifies both the benzene and VOC emissions and emission reductions. Data that have become available since proposal in general are insufficient in that they do not estimate VOC emission factors for all types of benzene-service equipment and that limited data are used where factors are estimated. In addition, these data were not gathered for the purpose of generating emission factors. Data were gathered, however, that confirm the assumption that the weight fraction benzene in the process line is indicative of the percent benzene in an equipment leak. In the refinery data base used at proposal, VOC emission factors were determined for all leak sources. The refinery data base resulted from an extensive study of fugitive emissions for the purpose of developing emission factors. This study provided a representative estimate of baseline fugitive emissions because the study occurred prior to the recent increase in awareness of fugitive emissions. Finally, the VOC emission factors developed in the refinery studies are not substantially different from the benzene unit and benzene-service equipment emission factors shown in Figures 2-1 through 2-3. Based on these considerations, EPA selected the refinery data and the concentration of benzene within the process stream as the basis for emission estimates for fugitive emission sources of benzene.

Comment: One commenter observed that the data base contains little benzene-specific information and added that the data that were available were inconsistent. The commenter noted that EPA has not completed any fugitive emission studies that deal specifically with benzene or benzene mixtures. The commenters asserted that EPA's discussions of control technology rely on transfer of technology from one industry segment to another without use of all literature data. In support of this position, the commenter cited two studies that report benzene emissions from single mechanical seals that are from 1/4 to 1/10 of the values used by EPA to represent VOC fugitive losses. These low values, according to the commenter, are consistent with the chemical industry's ability to comply with the OSHA workplace limit of 10 ppmv. The commenter recommended that EPA resolve the reasons for variations in fugitive loss data and suggested that several NIOSH studies on quantifying fugitive emissions might provide the basis for resolving the differences (IV-D-24). According to another commenter, the cumene data from the EPA screening study indicate that benzene fugitive emissions are actually 0.25 to 0.33 percent of plant losses as compared to 0.53 to 0.92 percent losses in the proposal BID (IV-K-1).

Response: EPA tested a variety of units in benzene service either as an individual source test or as part of larger screening and maintenance studies for refining and chemical process units. Approximately 3,400 valves and pumps in benzene units were tested. Benzene test data from petroleum refineries and chemical process units are described in the BID for the proposed standard, Appendix C. As described in the previous response, Table 2-7 presents new test data that have been reported since the completion of the BID for the proposed standard. In Table 2-7, 1,035 valves and pumps in benzene service are shown. Thus, EPA has adequately studied benzene-specific information.

In responding to the second part of the comment, EPA did rely on technology transfer between the refining and chemical industries in setting the standard. Technology transfer applies to the selection of control techniques, not the determination of emission estimates. There can be great variation in emission rates for fugitive emissions because of the nature of fugitive emissions. Most sources do not leak or have very low leak rates, and a few sources have high leak rates. It is very possible to calculate low emission rates for certain sources such as pump seals based on limited sampling of selected sources. EPA collected and evaluated data on fugitive emission sources and concluded that using the petroleum refining data (emission factors) and the concentration of benzene in the process stream is the best way to estimate benzene fugitive emissions. Since proposal, new data have confirmed this conclusion.

Addressing the final comment, estimation of benzene emissions based on plant losses has not been performed by EPA. The source and validity of data used to support these estimates is unknown.

2.8.5 Consistency with Other Regulations and Guidelines

Several commenters suggested that the regulation should be technically consistent with other regulations and guidelines.

Comment: One commenter recommended specifically that the standard be technically consistent with the new source performance standard

(NSPS) and the control technique guideline for VOC fugitive emissions in SOCMI facilities and compatible with OSHA standards (IV-D-24). Another commenter stated that the SOCMI NSPS and the benzene fugitive emissions standard are not equivalent in spite of what EPA maintains. The commenter noted that the actual monitoring and control requirements are identical, but the theoretical emission reduction is 87 percent for the proposed SOCMI NSPS and 73 percent for new sources in the proposed benzene standard, indicating that the former standard is stricter (IV-D-21, IV-F-1).

Response: The benzene fugitive emissions standard, the SOCMI VOC fugitive standard, and the SOCMI CTG's are technically consistent. They are all based on the same or compatible equipment requirements and the same work practice and monitoring requirements. For example, the leak detection and repair requirements for valves and pumps are similar. Although the draft SOCMI CTG specifies quarterly inspections and the NSPS and NESHAP specify monthly inspections of these sources, the basic control technique is the same. All three use the same type of instrument and require the same repair interval. In addition, all three require caps on open-ended lines. The equipment and work practice requirements are almost identical for the SOCMI fugitives NSPS and benzene fugitives NESHAP.

The second commenter (IV-D-21) correctly pointed out that the emission reduction estimated under the alternative selected as the basis of the proposed SOCMI VOC NSPS is 87 percent for new sources. However, the proposed benzene fugitive NESHAP was estimated to achieve an 80 percent emission reduction for new sources in the fifth year of the standard. The 73 percent emission reduction that the commenter quotes is the estimate for existing sources in benzene service. There is an obvious reason for the difference in the emission reduction estimates for the two standards. The standards are based on different model plants. The numbers of components (i.e., pumps, valves, etc.) per model unit are different for the standards. The emissions and emission reductions for each source type are different so that changing the relative number of sources will change the overall emission reduction even though the control techniques are identical.

Comment: One commenter stated that new provisions of the recommended refinery VOC fugitives NSPS should be incorporated into the proposed benzene fugitives NESHAP, since the two standards address similar types of equipment and sources (II-D-13).

Response: As discussed in Sections 2.3 and 2.4, many of the new provisions of the proposed refinery VOC fugitives standard have been incorporated into the benzene fugitives standard. For example, the equipment requirement of dual mechanical seals and barrier fluid systems has been deleted from the proposed standard for new pumps. Instead, the final standard requires a work practice standard (leak detection and repair) for new as well as existing pumps as in the proposed refinery VOC standard for new pumps. Another provision of the proposed refinery VOC standard that has been incorporated into the benzene fugitives standard is modifying the monitoring frequency for difficult-to-monitor valves when the monitoring requires elevation of personnel more than 2 meters above a permanent available support surface. An annual leak detection and repair program is required for these valves designated by the plant owner or operator to be difficult-to-monitor.

2.8.6 Incorporation of Other Comments or Documents

Comment: Many commenters requested that EPA incorporate as part of the administrative record their comments on other proposed EPA rulemakings and policies (IV-D-13; IV-D-24). One commenter requested that EPA include in the record the November 6, 1980, letter from R.R. Russell, Council on Wage and Price Stability, to D. Costle, EPA (IV-D-8). Another commenter requested that EPA make part of the record the June 1980 "Comparisons of Estimated and Actual Pollution Control Capital Expenditures for Selected Industries," by Putnam, Hayes, and Bartlett (IV-D-31).

Response: With regard to the request of the first group of commenters, EPA has incorporated these referenced comments on the proposed SOCMI VOC fugitives NSPS, SOCMI CTG, maleic anhydride, ethylbenzene/styrene, and benzene storage NESHAP's into the record for the benzene fugitives NESHAP. Table 2-8 lists citations for the comments and the EPA responses on other rulemakings and policies for which identical responses have been incorporated into the benzene fugitives standard. As requested by the second commenter (IV-D-8),

Table 2-8. COMMENTS AND EPA RESPONSES REFERENCED TO OTHER EPA RULINGS

EPA Ruling	Comment Letter Number from Docket No. A-79-27	Comment Page Number & Description	Location of Response
Benzene Storage NESHAP	IV-D-13 (API)	p.1 - General reference to comments.	Benzene Emissions from Benzene Storage Tanks - Background Information for Promulgated Standards (EPA-450/3-80-034b).
1. Benzene Storage NESHAP	IV-D-24 (Monsanto)	p.1 - General reference to comments.	1. Benzene Emissions from Benzene Storage Tanks - Background Information for Promulgated Standards (EPA-450/3-80-034b).
2. SOCMI CTG and NSPS for SOCMI VOC Fugitive Emissions			2. VOC Fugitive Emissions in Synthetic Organic Chemicals Manufacturing Industry - Background Information for Proposed Standards (EPA-450/3-80-033b).

EPA has included the referenced letter into the docket as A-79-27-IV-H-1. Finally, the report referenced by the third commenter (IV-D-31) has been included in the record as Docket Number A-79-27-IV-A-13.

2.8.7 Use of Alternative Control Systems

Comment: Two commenters questioned the provisions dealing with use of alternative control systems. One commenter felt that vendors should be allowed to provide alternative means of emission limitation (IV-D-21). The other commenter believed that the owner or operator should not be required to collect extensive data to determine the alternative means. According to the commenter, EPA should have sufficient data based on past studies to determine the alternative means of control methods (IV-D-24).

Response: The alternative means provisions of the proposed standard as stated in §61.244 do not directly allow vendors to apply for permission to use an alternative means of emission reduction. Section 61.244(b) lists guidelines for determination of alternatives to the equipment requirements of the standard. A primary consideration in this process is that "each owner or operator applying for permission shall be responsible for collecting and verifying test data for an alternative means of emission limitation...." A vendor could provide the owner or operator with the required test data; however, the ultimate responsibility for the accuracy of the data is with the owner or operator instead of the vendor. In order to increase efficiency in the process and to provide plant owners and operators the incentive to purchase improved control systems and equipment as they are developed, EPA decided to revise the final standard to allow a vendor or manufacturer to apply for alternatives to control systems or equipment. However, a determination of the alternative means may depend on how a plant owner or operator uses the control systems and equipment. Therefore, the application for permission to use an alternative means must come from the plant owner or operator unless a general determination of the alternative means with specific criteria can be made, in which case a vendor may request such a determination.

The logical way for a plant to document an alternative means of emission limitation is for the owner or operator to collect plant-specific data to show that the alternative achieves a reduction in emissions equivalent to requirements of the standard. Industry is in the best position to collect such data. EPA does not have adequate data to determine equivalence for every alternate control method, and, therefore, must rely on industry for such data. Moreover, industry has taken the position repeatedly that it should be allowed to select its own means of emission limitation whenever possible. It follows then that industry should collect its own test data in support of its alternative control techniques just as EPA has done in selecting the requirements of the standard.

2.8.8 Siting Criteria

Comment: One commenter criticized EPA for not considering the siting criteria proposed by the cancer policy in minimizing construction of new sources in populated areas or in subjecting new sources placed in populated areas to higher control requirements. Instead, the commenter stated that EPA has applied other approaches on a case-by-case basis in developing the standard. The commenter suggested that EPA should incorporate the siting criteria into the standard (IV-D-31).

Response: As at proposal, EPA has not decided how to implement the siting criteria discussed by the commenter. The siting criteria are not formulated and, accordingly, can not be implemented in this standard. They may be implemented later as discussed at proposal.

2.8.9 Withdrawal of the Standard

Comment: One commenter felt that the proposed rules and standards should be withdrawn in part because, individually, existing and new components of the sources in benzene service (such as pumps, compressors, and valves) have small or undetectable emission rates (IV-D-18).

Response: Emission rates examined on an individual source basis (i.e., pumps, valves, etc.) may appear small. However, when the large numbers of benzene-producing equipment in a refinery or chemical plant are taken into consideration, the emission levels can be quite significant on a process unit or plant-wide basis.

APPENDIX A

ANNUALIZED COSTS AND COST EFFECTIVENESS FOR BENZENE FUGITIVE EMISSION SOURCES

APPENDIX A

ANNUALIZED COSTS AND COST EFFECTIVENESS FOR BENZENE FUGITIVE EMISSION SOURCES

Tables A-1 through A-10 present annualized costs and cost effectiveness for various control techniques by benzene fugitive emission sources. Included are costs of implementing a leak detection and repair program at different intervals versus costs of equipment specifications. Tables A-11 and A-12 summarize for all equipment types the VOC and benzene emission reduction, average, and incremental cost effectiveness associated with each control technique. A discussion of the basis for the selection of the control techniques for each fugitive emission source is presented in Section 2.3 of this document.

Table A-1. ANNUALIZED CONTROL COSTS FOR VALVES IN GAS/VAPOR SERVICE (May 1979 Dollars)

	CONTROL TECHNIQUE				
COSTS	Annual Inspections	Quarterly Inspections	Monthly Inspections	Sealed Bellows Valve New	Sealed Bellows Valve Existing
Installed Capital Cost	0	0	0	2,500[b]	3,700[b]
Annualized Capital					
A. Control Equipment[c]	0	0	0	408[d]	600[d]
B. Initial Leak Repair[e]	0.40	0.40	0.40	0	0
Annualized Operating Costs					
A. Maintenance	0	0	0	125[f]	185[f]
B. Miscellaneous	0	0	0	100[g]	148[g]
C. Labor					
1. Monitoring[h]	0.51	2.04	6.09	0	0
2. Leak Repair[i]	2.94	3.27	3.34	0	0
3. Administrative and Support[j]	1.38	2.12	3.77	0	0
Total Annual Cost Before Credit	5.23	7.83	13.60	633	933
Recovery Credit[k]	13	52	59	85	85
Net Annualized Cost[l]	(7.77)	(44.17)	(45.40)	548	848
Total Emission reduction (Mg/yr)					
VOC[m]	0.035	0.14	0.16	0.23	0.23
Benzene Model A[n]	0.022	0.088	0.1008	0.14	0.14
Benzene Model B[n]	0.019	0.077	0.088	0.13	0.13
Benzene Model C[n]	0.026	0.105	0.12	0.17	0.17
Cost Effectiveness ($Mg)[o]					
VOC[m]	(220)	(320)	(280)	2,400	3,700
Benzene Model A[n]	(350)	(500)	(450)	3,900	6,100
Benzene Model B[n]	(410)	(570)	(520)	4,200	6,500
Benzene Model C[n]	(290)	(420)	(380)	3,200	4,900
Weighted Average ($/Mg Benzene)[p] New	(350)	(500)	(450)	3,700	--
Weighted Average ($/Mg Benzene)[p] Existing	(350)	(510)	(460)	--	6,060

Table A-1. ANNUALIZED CONTROL COSTS FOR VALVES IN GAS/VAPOR SERVICE[a] (continued) (May 1979 Dollars)

[a] All costs and emission reduction estimates are for one piece of equipment in benzene service.

[b] Telecon. McInnis, J.R., PES, Inc., to V. Caton and C. Hetrick, Chempump Division of Crane, Warrington, PA. August 23, 1979. Cost of sealed bellows valve.

[c] Cost of monitoring instrument is not included in this analysis.

[d] Based on 10-year equipment life and 10 percent interest (CRF = 0.163).

[e] Annualized charge for initial leak repairs for a valve inspection program is obtained by: number of leaks x repair time x 15.50/hr x 1.4 (overhead) x 0.163 (CRF for initial repair, 10 years at 10 percent interest). Assume 10 percent of gas valves and 11 percent of light liquid valves leak in initial survey. Initial leak repair is constant for all monitoring intervals.

	# Valves	x	% leaking	=	# Leaks	x	Repair Time(hrs)	x	Labor Rate* ($/hr)	x	1.4	x	0.163	=	$/yr
Gas:	1	x	0.10	=	0.10	x	1.13	x	15.50	x	1.4		0.163		0.40
Light liquid:	1	x	0.11	=	0.11	x	1.13	x	15.50	x	1.4		0.163		0.44

*Includes wages plus 40 percent for labor-related administrative and overhead costs.

[f] 0.05 x capital cost.

[g] 0.04 x capital cost.

[h] Monitoring Labor Cost (from leak detection and repair (LDAR) model):

	# Gas Service Valves	x	Fraction Screened	=	# Valves Screened	x	Monitoring Time (hours)	x	Labor Rate ($/hr)	=	Monitoring Labor Cost ($/yr)
Annual:	1	x	0.99	=	0.99	x	2/60	x	15.50	=	0.51
Quarterly:	1	x	3.94	=	3.94	x	2/60	x	15.50	=	2.04
Quarterly/ Monthly:	1	x	4.24	=	4.24	x	2/60	x	15.50	=	2.19
Monthly:	1	x	11.79	=	11.79	x	2/60	x	15.50	=	6.09

[i] Leak Repair Cost (from LDAR Model):

	# Gas-Service Valves	x	Fraction of Sources Operated On	=	# Leaks	x	Repair Time (Hours)	x	Labor Rate ($/hr)	=	Leak Repair Cost ($/yr)
Annual:	1	x	0.1685	=	0.168	x	1.13	x	15.50	=	2.94
Quarterly:	1	x	0.1866	=	0.187	x	1.13	x	15.50	=	3.27
Quarterly/ Monthly:	1	x	0.1877	=	0.188	x	1.13	x	15.50	=	3.29
Monthly:	1	x	0.1909	=	0.191	x	1.13	x	15.50	=	3.34

[j] 0.40 x (Monitoring cost + leak repair cost).

Table A-1. ANNUALIZED CONTROL COSTS FOR VALVES IN GAS/VAPOR SERVICE[a] (concluded)
(May 1979 Dollars)

[k] Recovery credit is based on total VOC emission reduction with a credit value of benzene. This credit is conservative since benzene is often a feed, and other chemicals that leak are more valuable. Recovery credit value is obtained by multiplying VOC emission reduction by $370/Mg benzene (2nd quarter, 1979 value).

[l] Total annual cost (before credit) - recovery credit.

[m] For gas service valves, the LDAR model estimates control efficiency (percent reduction in mass emissions). The uncontrolled emission factor for gas service valves is derived from refinery data (Docket No. A-79-27-II-A-30, p. 266).

	Emission Factor (kg/day)		Percent Reduction		Conversion to Mg/yr		Total VOC Emission Reduction (Mg/yr)
Annual:	0.64	x	0.149	x	0.365	=	0.035
Quarterly:	0.64	x	0.597	x	0.365	=	0.14
Quarterly/ Monthly:	0.64	x	0.611	x	0.365	=	0.14
Monthly:	0.64	x	0.703	x	0.365	=	0.16

For sealed bellows valves, an uncontrolled emission factor of 0.64 kg/day and 100 percent control efficiency are assumed.

[n] Benzene emission reduction and cost effectiveness estimates are presented for each model unit, based on the percentage of benzene in each process: A = 63 percent benzene, B = 55 percent benzene, C = 75 percent benzene.

[o] Obtained by dividing net annualized cost by total VOC and benzene emission reductions.

[p] Weighted Average Cost Effectiveness for New and Modified/Reconstructed (M/R) Model Units =

$$\frac{\text{Net Annual Cost (\$/yr)}}{\begin{matrix}\text{VOC Emission}\\ \text{Reduction x}\\ \text{(Mg/yr)}\end{matrix} \dfrac{\left(\begin{matrix}\text{\# of New \&}\\ \text{M/R Model A's}\end{matrix} \text{ x } \begin{matrix}\text{\% Benzene}\\ \text{in A}\end{matrix}\right) + \left(\begin{matrix}\text{\# of New \&}\\ \text{M/R Model B's}\end{matrix} \text{ x } \begin{matrix}\text{\% Benzene}\\ \text{in B}\end{matrix}\right) + \left(\begin{matrix}\text{\# New \&}\\ \text{M/R Model C's}\end{matrix} \text{ x } \begin{matrix}\text{\% Benzene}\\ \text{in C}\end{matrix}\right)}{\begin{matrix}\text{\# of New \& M/R}\\ \text{Model Unit A's}\end{matrix} + \begin{matrix}\text{\# of New \& M/R}\\ \text{Model Unit B's}\end{matrix} + \begin{matrix}\text{\# New \& M/R}\\ \text{Model Unit C's}\end{matrix}}}$$

$$= \frac{\text{Net Annual Cost (\$/yr)}}{\begin{matrix}\text{VOC Emission}\\ \text{Reduction}\\ \text{(Mg/yr)}\end{matrix} \text{ x } \dfrac{42(0.63) + 7(0.55) + 11(0.75)}{42 + 7 + 11}}$$

$$= \frac{\text{Net Annual Cost (\$/yr)}}{\begin{matrix}\text{VOC Emission}\\ \text{Reduction}\\ \text{(Mg/yr)}\end{matrix} \text{ x } 0.64}$$

Weighted Average Cost Effectiveness for Existing Model Units =

$$\frac{\text{Net Annual Cost (\$/yr)}}{\begin{matrix}\text{VOC Emission}\\ \text{Reduction x}\\ \text{(Mg/yr)}\end{matrix} \dfrac{\left(\begin{matrix}\text{\# of Existing}\\ \text{Model A's}\end{matrix} \text{ x } \begin{matrix}\text{\% Benzene}\\ \text{in A}\end{matrix}\right) + \left(\begin{matrix}\text{\# of Existing}\\ \text{Model B's}\end{matrix} \text{ x } \begin{matrix}\text{\% Benzene}\\ \text{in B}\end{matrix}\right) + \left(\begin{matrix}\text{\# of Existing}\\ \text{Model C's}\end{matrix} \text{ x } \begin{matrix}\text{\% Benzene}\\ \text{in C}\end{matrix}\right)}{\begin{matrix}\text{\# of Existing}\\ \text{Model Unit A's}\end{matrix} + \begin{matrix}\text{\# of Existing}\\ \text{Model Unit B's}\end{matrix} + \begin{matrix}\text{\# Existing}\\ \text{Model Unit C's}\end{matrix}}}$$

$$= \frac{\text{Net Annual Cost (\$/yr)}}{\begin{matrix}\text{VOC Emission}\\ \text{Reduction}\\ \text{(Mg/yr)}\end{matrix} \text{ x } \dfrac{131(0.63) + 75(0.55) + 18(0.75)}{131 + 75 + 18}}$$

$$= \frac{\text{Net Annual Cost (\$/yr)}}{\begin{matrix}\text{VOC Emission}\\ \text{Reduction}\\ \text{(Mg/yr)}\end{matrix} \text{ x } 0.62}$$

Table A-2. ANNUALIZED CONTROL COSTS FOR VALVES IN LIQUID SERVICE[a]
(May 1979 Dollars)

	CONTROL TECHNIQUE				
				Sealed Bellows Valve	
COSTS	Annual Inspections	Quarterly Inspections	Monthly Inspections	New	Existing
Installed Capital Cost	0	0	0	2,500[b]	3,700[b]
Annualized Capital A. Control Equipment[c]	0	0	0	408[d]	600[d]
B. Initial Leak Repair[e]	0.44	0.44	0.44	0	0
Annualized Operating Costs A. Maintenance	0	0	0	125[f]	185[f]
B. Miscellaneous	0	0	0	1009	1489
C. Labor 1. Monitoring[h]	0.51	2.04	6.09	0	0
2. Leak Repair[i]	2.96	3.27	3.34	0	0
3. Administrative and Support[j]	1.39	2.12	3.77	0	0
Total Annual Cost Before Credit	5.30	7.87	13.64	633	933
Recovery Credit[k]	7.4	22	26	33	33
Net Annualized Cost[l]	(2.10)	(14.13)	(12.36)	600	900
Total Emission reduction (Mg/yr) VOC[m]	0.020	0.06	0.069	0.09	0.09
Benzene Model A[n]	0.013	0.038	0.043	0.050	0.060
Benzene Model B[n]	0.011	0.033	0.038	0.050	0.050
Benzene Model C[n]	0.015	0.045	0.052	0.068	0.068
Cost Effectiveness ($Mg)[o] VOC[m]	(110)	(240)	(180)	6,700	10,000
Benzene Model A[n]	(160)	(370)	(290)	10,000	15,000
Benzene Model B[n]	(190)	(430)	(330)	12,000	18,000
Benzene Model C[n]	(140)	(310)	(240)	8,800	13,000
Weighted Average New	(160)	(370)	(280)	10,300	--
($/Mg Benzene)[p] Existing	(180)	(380)	(290)	--	16,000

Table A-2. ANNUALIZED CONTROL COSTS FOR VALVES IN LIQUID SERVICE[a] (concluded)
(May 1979 Dollars)

[a - g]: See Table A-1, footnotes a through g.

[h] Monitoring Labor Cost (from LDAR model):

	Light Liquid # Valves	x	Fraction Screened	=	# Valves Screened	x	Monitoring Time (hours)	x	Labor Rate ($/hr)	=	Monitoring Labor Cost ($/yr)
Annual:	1	x	0.99	=	0.99	x	2/60	x	15.50	=	0.51
Quarterly:	1	x	3.94	=	3.94	x	2/60	x	15.50	=	2.04
Quarterly/ Monthly:	1	x	4.24	=	4.24	x	2/60	x	15.50	=	2.19
Monthly:	1	x	11.79	=	11.79	x	2/60	x	15.50	=	6.09

[i] Leak Repair Cost (from LDAR Model):

	# Light Liquid Valves	x	Fraction of Sources Operated On	=	# Leaks	x	Repair Time (Hours)	x	Labor Rate ($/hr)		Leak Repair Cost ($ yr)
Annual:	1	x	0.1686	=	0.169	x	1.13	x	15.50	=	2.96
Quarterly:	1	x	0.1867	=	0.187	x	1.13	x	15.50	=	3.27
Quarterly/ Monthly:	1	x	0.1878	=	0.188	x	1.13	x	15.50	=	3.29
Monthly:	1	x	0.1909	=	0.191	x	1.13	x	15.50	=	3.34

j - 1: See Table A-1, footnotes j through 1.

[m] For light liquid valves, the LDAR model estimates percent reduction in mass emissions. The emission factor for light liquid valves is derived from refinery data (Docket No. A-79-27-II-A-30, p. 266).

Inspection Interval	Emission Factor (kg/day)	x	Percent Reduction	x	Conversion to Mg/yr	=	Total VOC Emission Reduction (Mg/yr)
Annual:	0.26	x	0.212	x	0.365	=	0.020
Quarterly:	0.26	x	0.627	x	0.365	=	0.059
Quarterly/ Monthly:	0.26	x	0.640	x	0.365	=	0.061
Monthly:	0.26	x	0.725	x	0.365	=	0.069

For sealed bellows valves, an emission factor of 0.26 kg/day and 100 percent control efficiency are assumed.

[n] See Table A-1, footnote n.

[o] See Table A-1, footnote o.

[p] See Table A-1, footnote p.

Table A-3. ANNUALIZED CONTROL COSTS FOR PUMPS - NEW UNITS[a]
(May 1979 Dollars)

	CONTROL TECHNIQUE			
COSTS	Annual Inspections	Quarterly Inspections	Monthly Inspections	Dual Mechanical Seals with Barrier Fluid System and Valve Degassing Vents[b]
Installed Capital Cost				
A. Seal	0	0	0	590
B. Barrier Fluid System	0	0	0	1,530
C. Degassing Vents	0	0	0	4,090
Annualized Capital				
A. Control Equipment[c]				
1. Dual Mechanical Seals				
• Seal[d]	0	0	0	199
• Installation[e]	0	0	0	40
2. Barrier Fluid System[f]	0	0	0	249
3. Degassing Vents[f]	0	0	0	667
4. Replacement Seal[g]	40	46	49	0
B. Initial Leak Repair[h]	14	14	14	0
C. Initial Seal Replacement[i]	4.7	4.7	4.7	0
Annualized Operating Costs				
A. Maintenance[j]				
1. Dual Mechanical Seals	0	0	0	30
2. Barrier Fluid System	0	0	0	77
3. Degassing Vents	0	0	0	205
B. Miscellaneous[k]				
1. Dual Mechanical Seals	0	0	0	24
2. Barrier Fluid System	0	0	0	61
3. Degassing Vents	0	0	0	164

Table A-3. ANNUALIZED CONTROL COSTS FOR PUMPS - NEW UNITS[a] (continued)
(May 1979 Dollars)

	CONTROL TECHNIQUE			
COSTS	Annual Inspections	Quarterly Inspections	Monthly Inspections	Dual Mechanical Seals with Barrier Fluid System and Valve Degassing Vents[b]
C. Labor				
1. Monitoring[l]	10	17	38	0
2. Leak Repair[m]	84	97	102	0
3. Administrative and Support[n]	38	46	56	0
Total Annual Cost Before Credit	191	225	264	1,716
Recovery Credit[o]	78	260	300	366
Net Annualized Cost[c,p]	113	(35)	(36)	1,350
Total Emission Reduction (Mg/yr)				
VOC[q]	0.21	0.70	0.82	0.99
Benzene Model A[r]	0.13	0.44	0.52	0.62
Benzene Model B[r]	0.12	0.39	0.45	0.54
Benzene Model C[r]	0.16	0.53	0.62	0.74
Cost Effectiveness ($/Mg)[s]				
VOC	540	(50)	(44)	1,400
Benzene Model A[r]	870	(80)	(69)	2,200
Benzene Model B[r]	940	(90)	(80)	2,500
Benzene Model C[r]	710	(66)	(58)	1,800
Weighted Average ($/Mg Benzene)[t]	870	(78)	(69)	2,100

Table A-3. ANNUALIZED CONTROL COSTS FOR PUMPS - NEW UNITS[a] (continued)
(May 1979 Dollars)

[a] See Table A-1, footnote a.

[b] Letter from J.A. Pearson, The Goodyear Tire and Rubber Company, to J.R. Farmer, U.S. EPA. November 16, 1979. (Docket No. A-79-27-II-D-77). Pump costs from BID I, p. 8-5. New seal cost = $573-230 (single seal credit) + $246 (installation) = $590.

[c] See Table A-1, footnote c.

[d] Annualized cost of dual seal = 573 x 0.58 CRF = 332
Single seal credit = (230) x 0.58 CRF = (133).

[e] Sixteen hours installation at $15.50 per hour = $248 x 0.163 CRF = $40.

[f] See Table A-1, footnote d.

[g] Replacement seal costs 1/2 that of a new seal because the old seal has salvage value.
Annual cost = 1/2(225) = 113 (last quarter 1978). Cost index = $\frac{279.6}{266.6}$ = 1.05 x 113 = $119/seal replaced

(Reference: Fugitive Emission Sources of Organic Compounds--Additional Information on Emissions, Emission Reductions, and Costs, U.S. EPA, OAQPS, EPA-450/3-82-010. April 1982. p. 5-19.

For annual, quarterly, and monthly monitoring, number of leaks = 0.34, 0.39, and 0.41, respectively (see footnote m below).

[h] Annualized charge for initial leak repairs for inspection program is obtained by: number of leaks per component x repair time x $15.50/hr. x 1.4 (overhead) x 0.163 (CRF for initial repair over 10 years at 10 percent interest). Assume 24 percent of pumps leak in initial survey. Initial leak repair is constant for all monitoring intervals.
1 pump x 0.24 leaks/pump x 16 repair hrs/leak x $15.50/hr x 1.4 x 0.163 CRF = $13.58.

[i] Initial seal replacement cost = percent of pumps initially leaking x replacement seal cost x capital recovery factor (0.24 x $119 x 0.163 = $4.70).

[j-k] See Table A-1, footnotes f and g, respectively.

[l] Monitoring labor cost (from LDAR Model):

	# Pumps		Fraction Screened		# Pumps Screened		Monitoring* Time (hours)		Labor Rate ($/hr)		Monitoring Labor Cost per Source ($/yr)
Annual:	1	x	1	=	1	x	10/60	x	15.50	=	$3.
Quarterly:	1	x	4	=	4	x	10/60	x	15.50	=	$10.
Monthly:	1	x	12	=	12	x	10/60	x	15.50	=	$31.

*Assumes 2-man monitoring team per pump.
Weekly visual inspection cost = $7/yr for all inspection intervals (assumes 0.5 minutes/source, 52 times/yr, $15.50/hr).

[m] Leak repair cost (from LDAR model):

	# Pumps		Fraction of Sources Operated On		# Leaks		Repair Time (hr/leak)		Labor Rate ($/hr)		Leak Repair Cost ($/yr)
Annual:	1	x	0.3397	=	0.34	x	16	x	15.50		$84
Quarterly:	1	x	0.3943	=	0.39	x	16	x	15.50		$97
Monthly:	1	x	0.4080	=	0.41	x	16	x	15.50		$102

Table A-3. ANNUALIZED CONTROL COSTS FOR (Concluded)
PUMPS - NEW UNITS[a]
(May 1979 Dollars)

[n] See Table A-1, footnote j.

[o] See Table A-1, footnote k.

[p] See Table A-1, footnote l.

[q] The LDAR model estimates control efficiency (percent reduction in mass emissions) for pumps. The emission factor for pumps is derived from refinery data (Docket No. A-79-27-II-A-30, p. 266).

	Emission Factor (kg/day)	x	Percent Reduction	x	Conversion to Mg/yr	=	Total VOC Emission Reduction (Mg/yr)
Annual:	2.7	x	0.218	x	0.365	=	0.21
Quarterly:	2.7	x	0.709	x	0.365	=	0.70
Monthly:	2.7	x	0.833	x	0.365	=	0.82

*100 percent control efficiency is assumed for dual mechanical pump seal systems.

[r] See Table A-1, footnote n.

[s] See Table A-1, footnote o.

[t] See Table A-1, footnote p.

( ) denotes savings.

Table A-4. ANNUALIZED CONTROL COSTS FOR PUMPS - EXISTING UNITS[a]
(May 1979 Dollars)

	CONTROL TECHNIQUE			
COSTS	Annual Inspections	Quarterly Inspections	Monthly Inspections	Dual Mechanical Seals with Barrier Fluid System and Degassing Vents[b]
Installed Capital Cost				
A. Seal	0	0	0	870
B. Barrier Fluid System	0	0	0	1,530
C. Degassing Vents	0	0	0	4,090
Annualized Capital				
A. Control Equipment[c]				
1. Dual Mechanical Seals				
• Seal[d]	0	0	0	332
• Installation[e]	0	0	0	48
2. Barrier Fluid System[f]	0	0	0	249
3. Degassing Vents[f]	0	0	0	667
4. Replacement Seal[g]	40	46	49	0
B. Initial Leak Repair[h]	14	14	14	0
C. Initial Seal Replacement[i]	4.7	4.7	4.7	0
Annualized Operating Costs				
A. Maintenance[j]				
1. Dual Mechanical Seals	0	0	0	44
2. Barrier Fluid System	0	0	0	37
3. Degassing Vents	0	0	0	205
B. Miscellaneous[k]				
1. Dual Mechanical Seals	0	0	0	35
2. Barrier Fluid System	0	0	0	29
3. Degassing Vents	0	0	0	164

Table A-4. ANNUALIZED CONTROL COSTS FOR PUMPS - EXISTING UNITS[a] (Continued)
(May 1979 Dollars)

	CONTROL TECHNIQUE			
COSTS	Annual Inspections	Quarterly Inspections	Monthly Inspections	Dual Mechanical Seals with Barrier Fluid System and Degassing Vents[b]
C. Labor				
1. Monitoring[l]	10	17	38	0
2. Leak Repair[m]	84	97	102	0
3. Administrative and Support[n]	38	46	56	0
Total Annual Cost Before Credit	191	225	264	1,810
Recovery Credit[o]	78	260	300	366
Net Annualized Cost[c,p]	113	(35)	(36)	1,444
Total Emission Reduction (Mg/yr)				
VOC[q]	0.21	0.70	0.82	0.99
Benzene Model A[r]	0.13	0.44	0.52	0.62
Benzene Model B[r]	0.12	0.39	0.45	0.54
Benzene Model C[r]	0.16	0.53	0.62	0.74
Cost Effectiveness ($/Mg)[s]				
VOC	540	(50)	(44)	1,500
Benzene Model A[r]	870	(80)	(69)	2,300
Benzene Model B[r]	940	(90)	(80)	2,700
Benzene Model C[r]	710	(66)	(58)	1,900
Weighted Average ($/Mg Benzene)[t]	870	(81)	(71)	2,400

Table A-4. ANNUALIZED CONTROL COSTS FOR (Concluded)
PUMPS - EXISTING UNITS[a]
(May 1979 Dollars)

[a] All costs and emission reduction estimates are for one light liquid pump in benzene service.

[b] Letter from J.A. Pearson, The Goodyear Tire and Rubber Company, to J.R. Farmer, U.S. EPA. November 16, 1979. (Docket No. A-79-27-II-D-77) Pump costs from BID I, p. 8-5. Capital cost of retrofitting an existing pump seal = \$573 + \$297 (installation) = \$870.

[c] See Table A-1, footnote c.

[d] Annualized cost of dual seal = \$573 x 0.58 CRF = \$332.

[e] Nineteen hours installation at \$15.50 per hour = \$295 x .163 CRF = \$48.

[f] See Table A-1, footnote d.

[g] See Table A-3, footnote g.

[h] See Table A-3, footnote h.

[i] Initial seal repair cost: percent of pumps initially leaking x replacement seal cost x capital recovery factor (0.24 x \$119 x 0.163 = \$4.70).

[j-k] See Table A-1, footnotes f and g, respectively.

[l] See Table A-3, footnote l.

[m] See Table A-3, footnote m.

[n] See Table A-1, footnote j.

[o] See Table A-1, footnote k.

[p] See Table A-1, footnote l.

[q] See Table A-3, footnote q.

[r] See Table A-1, footnote n.

[s] See Table A-1, footnote o.

[t] See Table A-1, footnote p.

( ) denotes savings.

Table A-5. ANNUALIZED CONTROL COSTS FOR COMPRESSORS - NEW AND EXISTING UNITS[a] (May 1979 Dollars)

COSTS	CONTROL TECHNIQUE Degassing Reservoir Vents
Installed Capital Cost	7,300[b]
Annualized Capital	
A. Control Equipment[c]	1,190
B. Initial Leak Repair[d]	0
Annualized Operating Costs	
A. Maintenance[e]	365
B. Miscellaneous[f]	292
C. Labor[g]	
1. Monitoring	0
2. Leak Repair	0
3. Administrative and Support	0
Total Annual Cost Before Credit	1,847
Recovery Credit[h]	2,040
Net Annualized Cost[i]	(193)
Total Emission Reduction (Mg/yr)	
VOC[j]	5.5
Benzene Model A[k]	3.5
Benzene Model B[k]	3.0
Benzene Model C[k]	4.1
Cost Effectiveness ($/Mg)[l]	
VOC[k]	(35)
Benzene Model A[k]	(55)
Benzene Model B[k]	(64)
Benzene Model C[k]	(47)
Weighted Average ($/Mg Benzene)[m]	New (55) Existing (57)

Table A-5. ANNUALIZED CONTROL COSTS FOR COMPRESSORS - NEW AND EXISTING UNITS[a] (Concluded)
(May 1979 Dollars)

[a] See Table A-1, footnote a.

[b] Cost per seal. From: Organic Chemical Manufacturing Volume 3: Storage, Fugitive, and Secondary Sources," EPA-450/3-80-025, December 1980. Cost updates from Chemical Engineering. Economic Indicators, 86(16):7. July 30, 1979. Costs have same basis as pump seals with a single compressor seal connected to a vent. The compressor seal area could be vented directly to a control device at similar cost.

[c] See Table A-1, footnote d.

[d] No initial leak repair charges for equipment specification.

[e-f] See Table A-1, footnotes f and g, respectively.

[g] No monitoring or leak repair labor costs are incurred for equipment specification.

[h] See Table A-1, footnote K.

[i] See Table A-1, footnote l.

[j] VOC emission reduction is based on an uncontrolled emission factor of 15 kg/day and assumes 100 percent control efficiency for compressor degassing reservoir vents.

[k] See Table A-1, footnote n.

[l] See Table A-1, footnote o.

[m] See footnote p, Table A-1.
( ) denotes savings.

Table A-6. ANNUALIZED CONTROL COSTS FOR PRESSURE RELIEF DEVICES - NEW UNITS[a]
(May 1979 Dollars)

	CONTROL TECHNIQUE					
			Rupture Disk System			
COSTS	Quarterly Inspections	Monthly Inspections	Block Valve	3-way Valve	O-Ring	Closed Vent System to Flare
Installed Capital Cost	0	0	1,810[b]	3,740[c]	220[d]	2,120[e]
Annualized Capital						
A. Control Equipment	--[f]	--[f]	380[g]	695[g]	36[r]	350[r]
B. Initial Leak Repair	0	0	0	0	0	0
Annualized Operating Costs						
A. Maintenance[h]	--[f]	--[f]	90	190	11	110
B. Miscellaneous[i]	--[f]	--[f]	70	150	9	85
C. Labor						
1. Monitoring[j]	17	50	0	0	0	0
2. Leak Repair	0	0	0	0	0	0
3. Administrative and Support[k]	7	20	0	0	0	0
Total Annual Cost Before Credit	24	70	540	1,035	56	545
Recovery Credit[l]	340	370	520	520	520	520
Net Annualized Cost[f,m]	(316)	(300)	20	515	(464)	25
Total Emission Reduction (Mg/yr)						
VOC[n]	0.91	0.99	1.4	1.4	1.4	1.4
Benzene Model A[o]	0.57	0.62	0.88	0.88	0.88	0.88
Benzene Model B[o]	0.5005	0.54	0.77	0.77	0.77	0.77
Benzene Model C[o]	0.68	0.74	1.1	1.1	1.1	1.1
Cost Effectiveness ($/Mg)[p]						
VOC	(350)	(303)	14	370	(330)	18
Benzene Model A[o]	(550)	(480)	23	590	(530)	28
Benzene Model B[o]	(630)	(560)	26	670	(600)	32
Benzene Model C[o]	(460)	(410)	18	470	(420)	23
Weighted Average ($/Mg Benzene)[q]	(540)	(480)	22	590	(520)	28

Table A-6. ANNUALIZED CONTROL COSTS FOR PRESSURE RELIEF DEVICES (concluded) NEW UNITS[a]
(May 1979 Dollars)

[a] See Table A-1, footnote a.

[b] Refinery CTG. June 1978, p. 4-6 and cost update from Economic Indicators. Chemical Engineering. 86(16):7. July 30, 1979.

[c] Memo from Cole, D.G., PES, Inc., to K.C. Hustvedt, U.S. EPA. Estimated Costs for Rupture Disk System with a 3-way Valve. July 29, 1981 (Docket No. A-80-44-II-B-35). Costs were adjusted to reflect May 1979 dollars.

[d] Cost of O-rings based on relief valve control costs in the EPA report, Additional Information Document (AID), Report Number EPA/3-80-033b, page 5-23. Costs were updated to reflect May 1979 dollars using cost indices from Chemical Engineering, Economic Indicators, April 9, 1979, and July 30, 1979.

[e] Cost of a closed vent system to transport the discharge or leakage of safety/relief valves to a flare based on costs in the EPA report, Additional Information Document (AID), Report Number EPA/3-80-033b, page 5-24. Costs were updated to reflect May 1979 dollars using cost indices from Chemical Engineering, Economic Indicators, April 9, 1979, and July 30, 1979.

[f] See Table A-1, footnote c.

[g] Obtained by multiplying capital recovery factor (2 years, 10 percent interest = 0.58) by capital cost for rupture disk and capital recovery factor (10 years, 10 percent interest = 0.163) by capital cost for all other equipment (rupture disk holder, piping, valves, pressure relief valve).

[h-i] See Table A-1, footnotes f and g, respectively.

[j] Monitoring labor hours (i.e., # workers x # components x time to monitor x times monitored per year) x $15.50 per hour. Assumes 2-man monitoring team per relief valve, 8 minutes monitoring time per valve, monitored quarterly or monthly.

[k] See Table A-1, footnote j.

[l] See Table A-1, footnote k.

[m] See Table A-1, footnote l.

[n] VOC emission reduction is based on an uncontrolled emission factor of 3.9 kg/day and assumes 64 percent efficiency for quarterly inspections, 68 percent efficiency for monthly inspections, and 100 percent efficiency for equipment controls.

[o] See Table A-1, footnote n.

[p] See Table A-1, footnote o.

[q] See Table A-1, footnote p.

[r] See Table A-1, footnote d.

Table A-7. ANNUALIZED CONTROL COSTS FOR PRESSURE RELIEF DEVICES - EXISTING UNITS[a]

(May 1979 Dollars)

	CONTROL TECHNIQUE					
			Rupture Disk System			
COSTS	Quarterly Inspections	Monthly Inspections	Block Valve	3-way Valve	O-Ring	Closed Vent System to Flare
Installed Capital Cost	0	0	3,310[b]	4,380[c]	220[d]	2,120[e]
Annualized Capital						
A. Control Equipment	--[f]	--[f]	620[g]	800[g]	36[r]	350[r]
B. Initial Leak Repair	0	0	0	0	0	0
Annualized Operating Costs						
A. Maintenance[h]	--[f]	--[f]	170	220	11	110
B. Miscellaneous[i]	--[f]	--[f]	130	180	9	85
C. Labor						
1. Monitoring[j]	17	50	0	0	0	0
2. Leak Repair	0	0	0	0	0	0
3. Administrative and Support[k]	7	20	0	0	0	0
Total Annual Cost Before Credit	24	70	920	1,200	56	545
Recovery Credit[l]	340	370	520	520	520	520
Net Annualized Cost[f,m]	(316)	(300)	400	680	(464)	25
Total Emission Reduction (Mg/yr)						
VOC[n]	0.91	0.99	1.4	1.4	1.4	1.4
Benzene Model A[o]	0.57	0.62	0.88	0.88	0.88	0.88
Benzene Model B[o]	0.5005	0.54	0.77	0.77	0.77	0.77
Benzene Model C[o]	0.68	0.74	1.1	1.1	1.1	1.1
Cost Effectiveness ($/Mg)[p]						
VOC	(350)	(303)	290	490	(330)	18
Benzene Model A[o]	(550)	(480)	450	770	(530)	28
Benzene Model B[o]	(630)	(560)	520	880	(600)	32
Benzene Model C[o]	(460)	(410)	360	620	(420)	23
Weighted Average ($/Mg Benzene)[q]	(560)	(490)	460	780	(520)	28

Table A-7. ANNUALIZED CONTROL COSTS FOR PRESSURE RELIEF DEVICES (concluded)
EXISTING UNITS[a]
(May 1979 Dollars)

[a] See Table A-6, footnote a.

[b] See Table A-6, footnote b.

[c] See Table A-6, footnote c.

[d] See Table A-6, footnote d.

[e] See Table A-6, footnote e.

[f] See Table A-1, footnote c.

[g] See Table A-6, footnote g.

[h-i] See Table A-1, footnotes f and g, respectively.

[j] See Table A-6, footnote j.

[k] See Table A-6, footnote k.

[l] See Table A-1, footnote k.

[m] See Table A-1, footnote l.

[n] See Table A-6, footnote n.

[o] See Table A-1, footnote n.

[p] See Table A-1, footnote o.

[q] See Table A-1, footnote p.

[r] See Table A-1, footnote d.

Table A-8. ANNUALIZED CONTROL COSTS FOR OPEN-ENDED LINES - NEW AND EXISTING UNITS[a]
(May 1979 Dollars)

	CONTROL TECHNIQUE
COSTS	Caps on Open Ends
Installed Capital Cost[b]	50
Annualized Capital	
A. Control Equipment[c]	8
B. Initial Leak Repair	0
Annualized Operating Costs	
A. Maintenance[d]	3
B. Miscellaneous[e]	2
C. Labor	
1. Monitoring	0
2. Leak Repair	0
3. Administrative and Support	0
Total Annual Cost Before Credit	13
Recovery Credit[f]	7.4
Net Annualized Cost[g]	5.6
Total Emission Reduction (Mg/yr)	
VOC[h]	0.02008
Benzene Model A[i]	0.013
Benzene Model B[i]	0.011
Benzene Model C[i]	0.015
Cost Effectiveness ($/Mg)[j]	
VOC	280
Benzene Model A[i]	430
Benzene Model B[i]	510
Benzene Model C[i]	370
Weighted Average ($/Mg Benzene)[k]	New 430 Existing 470

Table A-8. ANNUALIZED CONTROL COSTS FOR OPEN-ENDED LINES - (concluded) NEW AND EXISTING UNITS[a]
(May 1979 Dollars)

[a] See Table A-1, footnote a.

[b] Organic Chemical Manufacturing Volume 3: Storage, Fugitive, and Secondary Sources, EPA-450/3-80-025, December 1980. (Cost updates from Chemical Engineering. Economic Indicators. April 23, 1979, and July 30, 1979).

[c] See Table A-1, footnote d.

d - [e] See Table A-1, footnotes f and g, respectively.

[f] See Table A-1, footnote k.

[g] See Table A-1, footnote l.

[h] VOC emission reduction is based on an uncontrolled emission factor of 0.055 kg/day and assumes 100 percent control efficiency.

[i] See Table A-1, footnote n.

[j] See Table A-1, footnote o.

[k] See Table A-1, footnote p.

Table A-9. ANNUALIZED CONTROL COSTS FOR SAMPLING CONNECTIONS - NEW AND EXISTING UNITS[a]

(May 1979 Dollars)

	CONTROL TECHNIQUE
COSTS	Closed-Purge Sampling Systems
Installed Capital Cost[b]	480
Annualized Capital	
A. Control Equipment[c]	78
B. Initial Leak Repair	0
Annualized Operating Costs	
A. Maintenance[d]	24
B. Miscellaneous[e]	19
C. Labor	
1. Monitoring	0
2. Leak Repair	0
3. Administrative and Support	0
Total Annual Cost Before Credit	121
Recovery Credit[f]	48
Net Annualized Cost[g]	73
Total Emission Reduction (Mg/yr)	
VOC[h]	0.13
Benzene Model A[i]	0.082
Benzene Model B[i]	0.072
Benzene Model C[i]	0.098
Cost Effectiveness ($/Mg)[j]	
VOC	560
Benzene Model A[i]	890
Benzene Model B[i]	1,010
Benzene Model C[i]	740
Weighted Average ($/Mg Benzene)[k]	New 880 Existing 900

Table A-9. ANNUALIZED CONTROL COSTS FOR SAMPLING CONNECTIONS - (concluded)
NEW AND EXISTING UNITS[a]
(May 1979 Dollars)

[a] See Table A-1, footnote a.

[b] Organic Chemical Manufacturing Volume 3: Storage, Fugitive, and Secondary Sources, EPA-450/3-80-025, December 1980. Costs were updated to reflect May 1979 dollars using Economic Indicators, Chemical Engineering. 86(9):7, April 23, 1979, and 86(16):7, July 30, 1979).

[c] See Table A-1, footnote d.

d - [e] See Table A-1, footnotes f and g, respectively.

[f] See Table A-1, footnote k.

[g] See Table A-1, footnote l.

[h] VOC emission reduction is based on an uncontrolled emission factor of 0.36 kg/day and assumes 100 percent control efficiency for closed-sampling systems.

[i] See Table A-1, footnote n.

[j] See Table A-1, footnote o.

[k] See Table A-1, footnote p.

Table A-10. ANNUALIZED CONTROL COSTS FOR PRODUCT ACCUMULATOR VESSELS[a] (May 1979 Dollars)

	CONTROL TECHNIQUE
COSTS	Closed Vent System
Installed Capital Cost[b]	2,700
Annualized Capital	
A. Control Equipment[c]	400
B. Initial Leak Repair	0
Annualized Operating Costs	
A. Maintenance[d]	140
B. Miscellaneous[e]	110
C. Labor	
1. Monitoring	0
2. Leak Repair	0
3. Administrative and Support	0
Total Annual Cost Before Credit	650
Recovery Credit[f]	0
Net Annualized Cost[g]	650
Total Emission Reduction (Mg/yr)	
VOC[h]	10.8
Benzene Model A[i]	6.8
Benzene Model B[i]	5.9
Benzene Model C[i]	8.1
Cost Effectiveness ($/Mg)	
VOC[j]	60
Benzene Model A[i]	96
Benzene Model B[i]	110
Benzene Model C[i]	80
Weighted Average[k] ($/Mg Benzene)	New 94 Existing 97

Table A-10. ANNUALIZED CONTROL COSTS FOR PRODUCT ACCUMULATOR VESSELS (concluded)

(May 1979 Dollars)

[a] See Table A-1, footnote a.

[b] Capital cost is based on 61 meters of 5.1 cm carbon steel pipe, $2,700 installed per vent.

[c] See Table A-1, footnote d.

[d] See Table A-1, footnote f.

[e] See Table A-1, footnote g.

[f] See Table A-1, footnote k. No recovered product credit is expected for accumulator vessels.

[g] See Table A-1, footnote l.

[h] VOC emission reduction is based on an uncontrolled emission factor of 29.5 kg/day and assumes a control efficiency of 100 percent for a closed vent system.

[i] See Table A-1, footnote n.

[j] See Table A-1, footnote o.

[k] See Table A-1, footnote p.

Table A-11. CONTROL COSTS PER MEGAGRAM OF TOTAL EMISSIONS REDUCED[a]

Fugitive Emission Source	Control Technique	Total Emission Reduction Per Source[b] (Mg/yr)	Average $/Mg[c]		Incremental $/Mg[d]	
			New	Existing	New	Existing
Valves in gas/vapor service	Annual leak detection and repair	0.035	(220)[e]	(220)[e]	(220)[e]	(220)[e]
	Quarterly leak detection and repair	0.14	(320)[e]	(320)[e]	(350)[e]	(350)[e]
	Monthly leak detection and repair	0.16	(280)[e]	(280)[e]	(62)[e]	(62)[e]
	Sealed bellows valves	0.23	2,400	3,700	8,500	13,000
Valves in light liquid service	Annual leak detection and repair	0.020	(110)[e]	(110)[e]	(110)[e]	(110)[e]
	Quarterly leak detection and repair	0.06	(240)[e]	(240)[e]	(300)[e]	(300)[e]
	Monthly leak detection and repair	0.069	(180)[e]	(180)[e]	200	200
	Sealed bellows valves	0.09	6,700	10,000	29,000	43,000
Pumps	Annual leak detection and repair	0.21	540	540	540	540
	Quarterly leak detection and repair	0.70	(50)[e]	(50)[e]	(302)[e]	(302)[e]
	Monthly leak detection and repair	0.82	(44)[e]	(44)[e]	(8)[e]	(8)[e]
	Dual mechanical seal systems	0.99	1,400	1,500	8,200	8,700
Compressors	Degassing reservoir vents	0.55	(35)[e]	(35)[e]	(35)[e]	(35)[e]
Pressure Relief Devices	Quarterly leak detection and repair	0.91	(350)[e]	(350)[e]	(350)[e]	(350)[e]
	Monthly leak detection and repair	0.99	(303)[e]	(303)[e]	200	200
	Rupture disk with block valves	1.4	14	290	780[f]	1,700[f]
	Rupture disk with 3-way valve	1.4	370	490	2,000[f]	2,400[f]
	O-Ring	1.4	(330)[e]	(330)[e]	(400)[e,f]	(400)[e,f]
	Closed vent system to flare	1.4	18	18	790[f]	790[f]
Open-ended Lines	Caps on open ends	0.02008	280	280	280	280
Sampling Connection Systems	Closed purge sampling	0.13	560	560	560	560
Product Accumulator Vessels	Closed vent system	10.8	60[e]	60[e]	60[e]	60[e]

Table A-11. CONTROL COSTS PER MEGAGRAM OF TOTAL EMISSIONS REDUCED (Concluded)

[a] Costs and emission reductions are based on one fugitive emission source. Total emissions include benzene and other VOC.

[b] Total emission reduction (Mg/yr) from Tables A-1 through A-10.

[c] Average dollars per megagram (cost effectiveness) = net annualized cost per component ÷ annual emission reduction per component.

[d] Incremental dollars per megagram = (net annualized cost of the control technique - net annualized cost of the next less restrictive control technique) ÷ (annual emission reduction control technique - annual emission reduction of the next less restrictive control technique).

[e] Values in parentheses represent savings.

[f] Incremental costs are based on comparing equipment costs with monthly leak detection and repair costs.

[g] Monthly program is compared to straight quarterly program.

Table A-12. CONTROL COSTS PER MEGAGRAM OF BENZENE REDUCED[a]

Fugitive Emission Source	Control Technique	Benzene Emission Reduction Per Source[b] (Mg/yr)		Average $/Mg Benzene[c]		Incremental $/Mg Benzene[d]	
		New	Existing	New	Existing	New	Existing
Valves in gas/vapor service	Annual leak detection and repair	0.022	0.022	(350)[e]	(350)[e]	(350)[e]	(350)[e]
	Quarterly leak detection and repair	0.089	0.087	(500)[e]	(510)[e]	(540)[e]	(560)[e]
	Monthly leak detection and repair	0.102	0.099	(450)[e]	(460)[e]	(95)[e]	(103)[e]
	Sealed bellows valves	0.15	0.14	3,700	6,100	12,000	22,000
Valves in light liquid service	Annual leak detection and repair	0.013	0.012	(160)[e]	(180)[e]	(160)[e]	(180)[e]
	Quarterly leak detection and repair	0.038	0.037	(370)[e]	(380)[e]	(480)[e]	(480)[e]
	Monthly leak detection and repair	0.044	0.043	(280)[e]	(290)[e]	300	300
	Sealed bellows valves	0.058	0.056	10,300	16,000	44,000	70,000
Pumps	Annual leak detection and repair	0.13	0.13	870	870	870	870
	Quarterly leak detection and repair	0.45	0.43	(78)[e]	(81)[e]	(460)[e]	(490)[e]
	Monthly leak detection and repair	0.52	0.51	(69)[e]	(71)[e]	14	13
	Dual mechanical seal systems	0.63	0.61	2,100	2,400	13,000	15,000
Compressors	Degassing reservoir vents	3.5	3.4	(55)[e]	(57)[e]	(55)[e]	(57)[e]
Pressure Relief Devices	Quarterly leak detection and repair	0.58	0.56	(540)[e]	(560)[e]	(540)[e]	(560)[e]
	Monthly leak detection and repair	0.63	0.61	(480)[e]	(490)[e]	320	320
	Rupture disk with block valves	0.90	0.87	22	460	1,200[f]	2,700[f]
	Rupture disk with 3-way valve	0.90	0.87	590	780	3,000[f]	3,800[f]
	O-Ring	0.90	0.87	(520)[e]	(600)[e]	(610)[e,f]	(630)[e,f]
	Closed vent system to flare	0.90	0.87	28	29	1,200[f]	1,300[f]
Open-ended Lines	Caps on open ends	0.013	0.012	430	470	430	470
Sampling Connection Systems	Closed purge sampling	0.083	0.081	880	900	880	900
Product Accumulator Vessels	Closed vent system	6.9	6.7	94	97	94	97

Table A-12. CONTROL COSTS PER MEGAGRAM OF BENZENE REDUCED (Concluded)

[a] Costs and emission reductions are based on one fugitive emission source in benzene service.

[b] The benzene emission reduction represents a weighted average of emission reductions for three model plants with different percentages of benzene in each process -- A = 63 percent, B = 55 percent, C = 75 percent. Weighted factors for new and existing units (0.64 and 0.62, respectively) are multiplied by the VOC emission reduction for each control technique.

[c] Average dollars per megagram (cost effectiveness) = net annualized cost per component ÷ annual benzene emission reduction per component.

[d] Incremental dollars per megagram = (net annualized cost of the control technique - net annualized cost of the next less restrictive control technique) ÷ (annual benzene emission reduction of control technique - annual benzene emission reduction of the next less restrictive control technique).

[e] Values in parentheses denote savings.

[f] Incremental costs are based on comparing equipment costs with monthly leak detection and repair costs.

APPENDIX B

MODEL FOR EVALUATING THE EFFECTS OF LEAK DETECTION AND REPAIR ON BENZENE FUGITIVE EMISSIONS FROM CERTAIN VALVES AND PUMPS

APPENDIX B - MODEL FOR EVALUATING THE EFFECTS OF LEAK DETECTION AND REPAIR ON BENZENE FUGITIVE EMISSIONS FROM CERTAIN VALVES AND PUMPS

B.1 INTRODUCTION

The purpose of Appendix B is to present a mathematical model for evaluating leak detection and repair (LDAR) programs. The model described in this appendix takes an empirical approach by incorporating recently available data on leak occurrence and recurrence and data on the effectiveness of simple in-line repair.[1]

B.2 DESCRIPTION OF MODEL

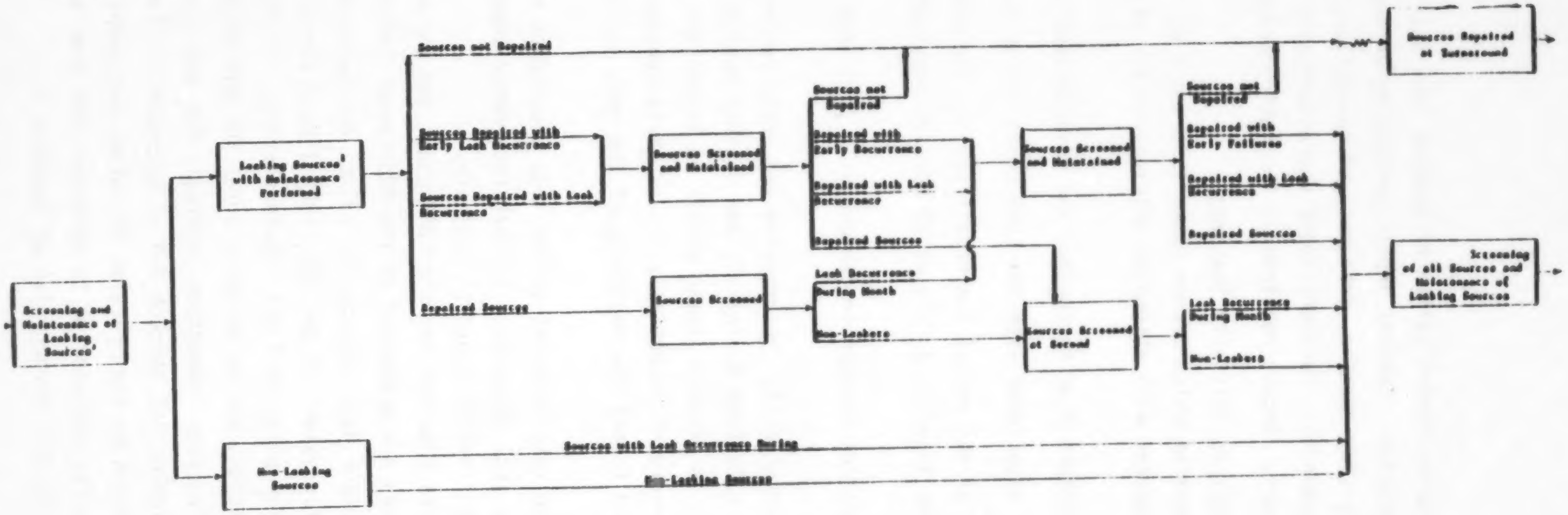
The modeled LDAR program is based on the premise that all sources at any given time are in one of four categories:

1) Non-leaking sources (sources screening less than the leak definition of 10,000 ppmv);
2) Leaking sources (sources screening equal to or greater than the leak definition);
3) Leaking sources which cannot be repaired on-line (screening equal to or greater than the leak definition) and are awaiting a shutdown, or process unit turnaround, for repair;
4) Repaired sources with early leak recurrence.

There are also four basic components to the model:

1) Screening of all sources except those in Category 3, above;
2) Maintenance of screened sources in Categories 2 and 4 above, in order to reduce emissions to less than 10,000 ppmv;
3) Rescreening of repaired sources;
4) Process unit turnaround during which maintenance is performed for sources in Categories 2, 3, and 4, above. Figure B-1 shows a schematic diagram of the LDAR program.

Since there are only four categories of sources, only four "leak rates" apply to all sources. The repaired sources experiencing early leak recurrence are assumed to have the same leak rate as sources which were unsuccessfully repaired. The LDAR model does not evaluate gradual changes in leak rates over time but assumes that all sources in a given category have the same average leak rate.



Screening and Maintenance of Leaking Sources²
Leaking Sources¹ with Maintenance Performed
Non-Leaking Sources
Sources not Repaired
Sources Repaired with Early Leak Recurrence
Sources Repaired with Leak Recurrence
Repaired Sources
Sources Screened and Maintained
Sources Screened
Sources not Repaired
Repaired with Early Recurrence
Repaired with Leak Recurrence
Repaired Sources
Leak Recurrence During Month
Non-Leakers
Sources Screened and Maintained
Sources Screened at Second
Sources not Repaired
Repaired with Early Failures
Repaired with Leak Recurrence
Repaired Sources
Leak Recurrence During Month
Non-Leakers
Sources with Leak Occurrence During
Non-Leaking Sources
Sources Repaired at Turnaround
Screening of all Sources and Maintenance of Leaking Sources

[1] Leaking sources include all sources which had leak occurrence, had experienced early failures, or had leak occurrence and remained leakers

[2] Except sources for which attempted maintenance was not successful.

Figure B-1. SCHEMATIC DIAGRAM OF MODELED LEAK DETECTION AND REPAIR PROGRAM

The LDAR model enables investigation of several leak detection and repair program scenarios. General inputs pertaining to the LDAR program itself may vary (for example, frequency of inspection, repairs, and process unit turnarounds). Further, input characteristics of the emission sources may vary. Inputs required in the latter group include:

1) The fraction of sources initially leaking;
2) The fraction of sources which become leakers during a period;
3) The fraction of sources with attempted maintenance for which repair was successful;
4) The emission reductions from successful and unsuccessful repair.

Other assumptions associated with the LDAR model are as follows:

1) All repairs occur at the end of the repair period; the effects associated with the time interval during which repairs occur are negligible;
2) Unsuccessfully repaired sources instantaneously fall into the unrepaired category;
3) Leaks other than unsuccessful maintenance and early recurrences occur at a linear rate with time during a given monthly period; the monthly occurrence rate is assumed linear within an inspection period;
4) A process unit turnaround essentially occurs instantaneously at the end of a quarter and before the beginning of the next monitoring period;
5) The leak recurrence rate is equal to the leak occurrence rate; sources that experience leak occurrence or leak recurrence immediately leak at the rate of the "leaking sources" category.

The input parameters required for the LDAR model and the outputs that the model calculates are presented in the Additional Information Document (AID).[2] The major data outputs for valves and pumps appear in Tables B-1 and B-2 for valves in gas and light liquid service and in Tables B-3 and B-4 for pumps in light liquid service. Tables B-1 and B-3 contain information used to estimate total VOC and benzene emission reductions at various inspection intervals for the cost analysis presented in Tables A-1 through A-4 of Appendix A. Tables B-2 and B-4 contain information on the fraction of valves and pumps screened and the fraction of sources operated on to determine the leak detection and repair costs in Tables A-1 through A-4 of Appendix A.

Table B-1. VALVE EMISSION FACTORS AND MASS EMISSION REDUCTIONS

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND FRACTIONAL REDUCTION
IN MASS EMISSIONS FOR VALVES BY TURNAROUND - MONTHLY UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
TURNAROUND	MEAN EMISSION-KG/HR	REDUCTION	MEAN EMISSION-KG/HR	REDUCTION
1	0.0088	0.673	0.0034	0.695
2	0.0080	0.703	0.0030	0.725

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND FRACTIONAL REDUCTION
IN MASS EMISSIONS FOR VALVES BY TURNAROUND - QUART/MONTH UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
TURNAROUND	MEAN EMISSION-KG/HR	REDUCTION	MEAN EMISSION-KG/HR	REDUCTION
1	0.0113	0.583	0.0043	0.611
2	0.0105	0.611	0.0040	0.640

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND FRACTIONAL REDUCTION
IN MASS EMISSIONS FOR VALVES BY TURNAROUND - QUARTERLY UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
TURNAROUND	MEAN EMISSION-KG/HR	REDUCTION	MEAN EMISSION-KG/HR	REDUCTION
1	0.0116	0.570	0.0044	0.599
2	0.0109	0.597	0.0041	0.627

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND FRACTIONAL REDUCTION
IN MASS EMISSIONS FOR VALVES BY TURNAROUND - YEARLY UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
TURNAROUND	MEAN EMISSION-KG/HR	REDUCTION	MEAN EMISSION-KG/HR	REDUCTION
1	0.0231	0.143	0.0088	0.204
2	0.0230	0.149	0.0087	0.212

Table B-2. FRACTION OF VALVES SCREENED AND OPERATED ON

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR VALVES BY YEAR
MONTHLY UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
YEAR	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	12.7728	0.2825	12.7594	0.2937
2	11.5686	0.2110	11.5553	0.2119
3	11.8974	0.1792	11.8972	0.1793
4	11.6917	0.2026	11.6915	0.2026
5	11.8991	0.1776	11.8991	0.1776

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR VALVES BY YEAR
QUART/MONTH UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
YEAR	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	5.2994	0.2776	5.3121	0.2888
2	4.1169	0.2065	4.1121	0.2074
3	4.3150	0.1771	4.3170	0.1773
4	4.1595	0.1983	4.1594	0.1983
5	4.2971	0.1756	4.2971	0.1756

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR VALVES BY YEAR
QUARTERLY UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
YEAR	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	4.9324	0.2760	4.9281	0.2872
2	3.8648	0.2051	3.8603	0.2060
3	3.9726	0.1762	3.9725	0.1764
4	3.9044	0.1970	3.9043	0.1970
5	3.9730	0.1748	3.9730	0.1748

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR VALVES BY YEAR
YEARLY UNITS

	GAS SERVICE		LIGHT LIQUID SERVICE	
YEAR	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	1.9900	0.2512	1.9890	0.2622
2	0.9749	0.1798	0.9738	0.1808
3	1.0000	0.1634	1.0000	0.1636
4	0.9837	0.1735	0.9836	0.1736
5	1.0000	0.1627	1.0000	0.1627

Table B-3. PUMP EMISSION FACTORS AND MASS EMISSION REDUCTIONS

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND FRACTIONAL REDUCTION
IN MASS EMISSIONS FOR PUMPS BY TURNAROUND - MONTHLY UNITS

	VOC SERVICE	
TURNAROUND	MEAN EMISSION-KG/HR	REDUCTION
1	0.0189	0.833
2	0.0189	0.833

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND FRACTIONAL REDUCTION
IN MASS EMISSIONS FOR PUMPS BY TURNAROUND - QUARTERLY UNITS

	VOC SERVICE	
TURNAROUND	MEAN EMISSION-KG/HR	REDUCTION
1	0.0328	0.709
2	0.0328	0.709

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND FRACTIONAL REDUCTION
IN MASS EMISSIONS FOR PUMPS BY TURNAROUND - YEARLY UNITS

	VOC SERVICE	
TURNAROUND	MEAN EMISSION-KG/HR	REDUCTION
1	0.0883	0.218
2	0.0883	0.218

Table B-4. FRACTION OF PUMPS SCREENED AND OPERATED ON

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SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR PUMPS BY YEAR
                                 MONTHLY UNITS

                        VOC SERVICE
             --------------------------------------------
              TOTAL FRACTION OF     TOTAL FRACTION OF
   YEAR       SOURCES SCREENED     SOURCES OPERATED ON
----------------------------------------------------------

    1            13.0000                 0.6480

    2            12.0000                 0.4080

    3            12.0000                 0.4080

    4            12.0000                 0.4080

    5            12.0000                 0.4080
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SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR PUMPS BY YEAR
                                QUARTERLY UNITS

                        VOC SERVICE
             --------------------------------------------
              TOTAL FRACTION OF     TOTAL FRACTION OF
   YEAR       SOURCES SCREENED     SOURCES OPERATED ON
----------------------------------------------------------

    1             5.0000                 0.6343

    2             4.0000                 0.3943

    3             4.0000                 0.3943

    4             4.0000                 0.3943

    5             4.0000                 0.3943
```

```
SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR PUMPS BY YEAR
                                 YEARLY UNITS

                        VOC SERVICE
             --------------------------------------------
              TOTAL FRACTION OF     TOTAL FRACTION OF
   YEAR       SOURCES SCREENED     SOURCES OPERATED ON
----------------------------------------------------------

    1             2.0000                 0.5797

    2             1.0000                 0.3397

    3             1.0000                 0.3397

    4             1.0000                 0.3397

    5             1.0000                 0.3397
```

B.3 REFERENCES

1. Wetherold, R.G., G.J. Langley, et.al. Evaluation of Maintenance for Fugitive VOC Emissions Control. U.S. EPA, Industrial Environmental Research Laboratory. EPA-600/52-81-080. May 1981. Docket Number A-79-27-IV-A-16.*

2. Fugitive Emission Sources of Organic Compounds--Additional Information on Emissions, Emission Reductions, and Costs. U.S. EPA, Office of Air Quality Planning and Standards, Emission Standards and Engineering Division. EPA-450/3-82-010. April 1982. Docket Number A-79-27-IV-A-24.*

*References can be located in Docket Number A-79-27 at the U.S. Environmental Protection Agency Library, Waterside Mall, Washington, D.C.

APPENDIX C

METHODOLOGY FOR ESTIMATING INCIDENCE OF LEUKEMIA AND MAXIMUM LIFETIME RISK FROM EXPOSURE TO FUGITIVE EMISSION SOURCES OF BENZENE

APPENDIX C

METHODOLOGY FOR ESTIMATING INCIDENCE OF LEUKEMIA AND MAXIMUM LIFETIME RISK FROM EXPOSURE TO FUGITIVE EMISSION SOURCES OF BENZENE

C.1 INTRODUCTION

The purpose of this appendix is to describe the methodology and to provide the information used to estimate the incidence of leukemia and maximum lifetime risk from population exposure to benzene emissions from fugitive emission sources. The methodology consists of four major components: estimation of annual average concentration patterns of benzene in the region surrounding each plant, estimation of the population exposed to each computed concentration, calculation of exposure by summing the products of the concentrations and associated populations, and calculation of annual leukemia incidence and maximum lifetime risk from the concentration and exposure estimates and a health effects estimate represented by a unit risk factor. Due to the assumptions made in each of these four steps of the methodology, there is uncertainty associated with the lifetime individual risk and leukemia incidence numbers calculated in this appendix. These uncertainties are explained in Section C.6 of this appendix. A description of the health effects and derivation of the unit risk factor for benzene is not included in this appendix; however, they are discussed in EPA docket number OAQPS 79-3 and Response to Public Comments on EPA's Listing of Benzene Under Section 112, EPA-450/5-82-003.

C.2 ATMOSPHERIC DISPERSION MODELING AND PLANT EMISSION RATES

The Human Exposure Model (HEM) was used to estimate concentrations of benzene around approximately 130 plants that contain fugitive emission sources of benzene.[1] The HEM estimates the annual average ground-level concentrations resulting from emissions from point and area sources. For point sources, the dispersion model within the HEM is a Gaussian model that uses the same basic dispersion algorithm as the climatological form of EPA's Climatological Dispersion Model.[2] Gaussian concentration files are used in conjunction with multi-year STAR data and annual emissions data to estimate annual average concentrations. Details on this aspect of the HEM can be found in Reference 1.

Seasonal or annual stability array (STAR) summaries are principal meteorological input to the HEM dispersion model. STAR data are standard climatological frequence-of-occurrence summaries formulated for use in EPA models and available for major U.S. sites from the National Climatic Center, Asheville, N.C. A STAR summary is a joint frequency of occurrence of wind speed stability and wind direction categories, classified according to the Pasquill stability categories. For this modeling analysis, annual STAR summaries were used.

The model receptor grid consists of 10 downwind distances located along 16 radials. The radials are separated by 22.5-degree intervals beginning with 0.0 degrees and proceeding clockwise to 337.5 degrees. The 10 downwind distances for each radial are 0.2, 0.3, 0.5, 0.7, 1.0, 2.0, 5.0, 10.0 15.0, and 20.0 kilometers. The center of the receptor grid for each plant was assumed to be the center as determined by review of maps. Industry provided confirmation where ambiguities existed.

Plant emission rates used as inputs to the dispersion model were calculated as follows: (1) three model process unit emission rates were developed; (2) model units were assigned to each plant according to the actual process unit composition of the plant; and (3) assigned model unit emission rates were summed for each plant to obtain the total plant benzene fugitive emission rate. Model unit emission rates are based upon data that reflect benzene emissions from fugitive emission sources, as described in Section 2.8.4 of this document. EPA Docket Number A-79-27-IV-B-11 explains the derivation of emission rates in greater detail.

Ordinarily the Industrial Source Complex - Long Term (ISC-LT) dispersion model would have been used to estimate benzene concentrations; however, the HEM model was used instead. The HEM tends generally to predict more conservative concentrations than the ISC-LT dispersion model. The ISC-LT model has been validated and is considered superior to the HEM. However, the ISC-LT model was not used in this analysis because the effort required to use properly the ISC-LT was not warranted, considering the uncertainties in the basic data available for the model (see Section 2.2.1.2 of this document). Because there are so many plants, the resources that would be required to model each one individually were considered unreasonable given that the difference in the more detailed results would not be great enough to alter the basic decisions of the standard. In order to evaluate the effect of using the HEM instead of the ISC-LT dispersion model, the ISC-LT model was used for nine plants and the results were compared with the HEM results. This comparison is described in Section C.7 and in more detail in Docket Number A-79-27-IV-B-18. The HEM output for all plants modeled is contained in the EPA Docket Number A-79-27-IV-B-15.

C.3 POPULATION AROUND PLANTS CONTAINING FUGITIVE EMISSION SOURCES OF BENZENE

The HEM was used to estimate the population that resides in the vicinity of each receptor coordinate surrounding each plant containing fugitive emission sources of benzene. A slightly modified version of the "Master Enumeration District List--Extended" (MED-X) data base is contained in the HEM and used for population pattern estimation. This data base is broken down into enumeration district/block group (ED/BG) values. MED-X contains the population centroid coordinates (latitude and longitude) and the 1970 population of each ED/BG in the United States (50 States plus the District of Columbia). For human exposure estimations, MED-X has been reduced from its complete form (including descriptive and summary data) to produce a randomly accessible computer file of the data necessary for the estimation. A separate file of county-level growth factors, based on 1978 estimates of the 1970 to 1980 growth factor at the county level, has also been created for use in estimating 1980 population figures for each ED/BG. The population "at risk" to benzene exposure was considered to be persons residing within 20 km of plants containing fugitive emission sources of benzene. The population around each plant was identified by specifying the geographical coordinates of that plant. Table C-1 presents the plants and locations for fugitive emission sources of benzene.

Table C-1. PLANTS AND LOCATIONS FOR FUGITIVE EMISSION SOURCES OF BENZENE

Plant	Location	Coordinates	
		Longitude	Latitude
Region II			
1. American Cyanamid	Boundbrook, NJ	74°06'04"	40°33'25"
2. DuPont	Gibbstown, NJ	75°17'50"	39°50'25"
3. Merck & Co.	Rahway, NJ	74°16'00"	40°37'00"
4. Reichhold[a]	Elizabeth, NJ	74°13'05"	40°39'15"
5. Standard Chlorine	Kearny, NJ	74°06'39"	40°45'03"
6. Tenneco[a]	Fords, NJ	74°19'08"	40°30'42"
7. Texaco	Westville, NJ	75°08'42"	39°52'05"
8. Ashland Oil	North Tonawanda, NY	78°55'27"	42°59'45"
9. ICC Industries	Niagara Falls, NY	79°00'55"	43°03'33"
10. Commonwealth Oil	Penuelas, PR	66°42'00"	18°04'00"
11. Phillips Puerto Rico	Guyama, PR	66°07'00"	17°59'00"
12. Puerto Rico Olefins	Penuelas, PR	66°42'00"	18°04'00"
13. Union Carbide	Penuelas, PR	66°42'00"	18°04'00"
14. Amerada Hess	St. Croix, VI	64°44'00"	17°45'00"
Region III			
15. Getty	Delaware City, DE	75°37'45"	39°35'15"
16. Standard Chlorine	Delaware City, DE	75°38'47"	39°33'54"
17. Sun-Olin	Claymont, DE	76°25'40"	39°48'20"
18. Continental Oil	Baltimore, MD	77°34'02"	39°14'19"
19. Atlantic Richfield	Beaver Valley, PA	80°21'20"	40°39'21"
20. Gordon Terminals	McKees Rocks, PA	80°03'10"	40°28'22"
21. Gulf Oil	Philadelphia, PA	75°12'31"	39°54'18"
22. Koppers[a]	Bridgeville, PA	80°04'41"	40°21'32"
23. Koppers	Petrolia, PA	79°42'30"	41°45'41"
24. Standard Oil (Ohio)/BP Oil	Marcus Hook, PA	75°25'26"	39°49'12"

Table C-1. PLANTS AND LOCATIONS FOR FUGITIVE EMISSION SOURCES OF BENZENE (Continued)

Plant	Location	Coordinates	
		Longitude	Latitude
Region III (concluded)			
25. Sun Oil	Marcus Hook, PA	75°24'51"	39°48'45"
26. U.S. Steel	Neville Island, PA	80°05'00"	40°30'00"
27. Allied Chemical	Moundsville, WV	80°48'04"	39°55'00"
28. American Cyanamid	Willow Island, WV	81°19'08"	39°21'45"
29. Ashland Oil[b]	Neal, WV	82°35'37"	38°22'07"
30. Mobay Chemical	New Martinsville, WV	80°49'50"	39°43'30"
31. PPG	Natrium, WV	80°51'06"	39°44'45"
32. Union Carbide	Institute, WV	81°47'05"	38°22'40"
33. Merck & Co.	Elkton, VA	78°39'03"	38°23'05"
Region IV			
34. Jim Walter Resources	Birmingham, AL	86°47'30"	33°35'30"
35. Reichhold Chemicals	Tuscaloosa, AL	87°28'21"	33°15'06"
36. Ashland Oil	Ashland, KY	82°36'32"	38°22'30"
37. B.F. Goodrich	Calvert City, KY	88°19'51"	37°03'19"
38. GAF	Calvert City, KY	88°24'48"	37°02'51"
39. Olin Corporation	Brandenburg, KY	86°07'15"	38°00'30"
40. Chevron	Pascagoula, MS	88°28'37"	30°19'04"
41. First Chemical	Pascagoula, MS	88°29'45"	30°20'57"
Region V			
42. Clark Oil	Blue Island, IL	87°42'07"	41°39'19"
43. Core-Lube	Danville, IL	87°32'30"	40°07'10"
44. Koppers[b]	Cicero, IL	87°38'45"	41°48'30"
45. Monsanto	Sauget, IL	90°10'11"	38°36'06"
46. National Distillers (U.S.I.)	Tuscola, IL	88°21'00"	39°47'53"
47. Northern Petrochemicals	Morris, IL	88°25'42"	41°21'28"
48. Reichhold Chemicals[a]	Morris, IL	88°17'56"	42°23'20"
49. Shell Oil	Wood River, IL	90°04'24"	38°50'26"

Table C-1. PLANTS AND LOCATIONS FOR FUGITIVE EMISSION SOURCES OF BENZENE (Continued)

Plant	Location	Coordinates	
		Longitude	Latitude
Region V (concluded)			
50. Union Oil (California)	Lemont, IL	88°00'10"	41°40'20"
51. Dow Chemical	Bay City, MI	83°52'22"	43°37'21"
52. Dow Chemical	Midland, MI	84°12'18"	43°35'42"
53. Sun Oil	Toledo, OH	83°31'40"	41°36'52"
Region VI			
54. Vertac/Transvaal	Jacksonville, AR	92°04'56"	34°55'36"
55. Allied Chemical	Geismar, LA	91°03'12"	30°12'55"
56. American Hoechst	Baton Rouge, LA	91°12'40"	30°33'03"
57. Cities Service	Lake Charles, LA	93°19'01"	30°10'58"
58. Continental Oil	Lake Charles, LA	93°16'35"	30°14'30"
59. Cos-Mar, Inc.	Carrville, LA	91°04'09"	30°14'16"
60. Dow Chemical	Plaquemine, LA	91°14'30"	30°19'50"
61. Exxon	Baton Rouge, LA	91°10'17"	30°29'14"
62. Gulf Coast Olefins	Taft, LA	90°26'23"	29°59'16"
63. Gulf Oil	Alliance, LA	89°58'26"	29°41'00"
64. Gulf Oil	Donaldsonville, LA	90°55'19"	30°05'44"
65. Pennzoil United (Atlas Processing)	Shreveport, LA	93°46'13"	32°28'12"
66. Rubicon	Geismar, LA	91°00'37"	30°11'06"
67. Shell Oil	Norco, LA	90°27'35"	29°59'42"
68. Tenneco	Chalmette, LA	89°58'19"	29°55'56"
69. Union Carbide	Taft, LA	90°27'15"	29°59'17"
70. Sun Oil	Tulsa, OK	96°01'15"	36°08'25"
71. Amerada Hess	Houston, TX	95°14'15"	29°41'39"
72. American Hoechst	Bayport, TX	95°01'15"	29°36'10"
73. American Petrofina of Texas	Port Arthur, TX	93°53'20"	29°57'30"

Table C-1. PLANTS AND LOCATIONS FOR FUGITIVE EMISSION SOURCES OF BENZENE (Continued)

Plant	Location	Coordinates	
		Longitude	Latitude
Region VI (continued)			
74. American Petrofina (Cosden Oil)	Big Spring, TX	101°24'55"	32°16'11"
75. American Petrofina/ Union Oil of California	Beaumont, TX	93°58'45"	30°00'00"
76. Atlantic Richfield	Channelview, TX	95°07'30"	29°50'00"
77. Atlantic Richfield (ARCO/Polymers)	Houston, TX	95°13'54"	29°43'10"
78. Atlantic Richfield (ARCO/Polymers)	Port Arthur, TX	93°58'15"	29°51'24"
79. Celanese	Pampa, TX	100°57'47"	35°32'07"
80. Charter International	Houston, TX	95°15'09"	29°40'17"
81. Coastal States Gas	Corpus Christi, TX	97°26'44"	27°48'42"
82. Corpus Christi Petrochemicals	Corpus Christi, TX	97°31'21"	27°50'02"
83. Cosden Oil	Groves, TX	93°52'58"	29°57'46"
84. Crown Central	Pasadena, TX	95°10'30"	29°44'40"
85. Denka (Petrotex)[b]	Houston, TX	283.5	3289.6
86. Dow Chemical(A)	Freeport, TX	95°19'55"	28°57'23"
87. Dow Chemical(B)	Freeport, TX	95°24'09"	28°59'17"
88. Dow Chemical	Orange, TX	93°45'14"	30°03'20"
89. DuPont	Beaumont, TX	94°01'40"	30°00'51"
90. DuPont	Orange, TX	93°44'44"	30°03'24"
91. Eastman Kodak	Longview, TX	94°41'24"	32°26'17"
92. El Paso Natural Gas	Odessa, TX	102°19'29"	31°49'27"
93. El Paso Products/ (Rexene Polyolefins)	Odessa, TX	102°20'00"	31°49'22"

Table C-1. PLANTS AND LOCATIONS FOR FUGITIVE EMISSION SOURCES OF BENZENE (Continued)

Plant	Location	Coordinates	
		Longitude	Latitude
Region VI (continued)			
94. Exxon	Baytown, TX	95°01'04"	29°44'50"
95. GATX Terminal Group	Houston, TX	95°13'29"	29°43'17"
96. Georgia-Pacific Corp.	Houston, TX	95°03'00"	29°37'20"
97. Goodyear Tire and Rubber	Bayport, TX	95°02'44"	29°39'43"
98. Gulf Oil Chemicals	Cedar Bayou, TX	94°55'10"	29°49'29"
99. Gulf Oil Chemicals	Port Arthur, TX	93°58'30"	29°51'30"
100. Hercules	McGregor, TX	97°16'30"	31°30'15"
101. Howell	San Antonio, TX	98°27'36"	29°20'51"
102. Independent Refining Corp.	Winnie, TX	94°20'28"	29°50'04"
103. Kerr-McGee Corp. (Southwestern)	Corpus Christi, TX	97°25'24"	27°48'16"
104. Marathon Oil	Texas City, TX	94°54'47"	29°22'21"
105. Mobil Oil	Beaumont, TX	94°03'30"	30°04'00"
106. Monsanto	Alvin (Chocolate Bayou)	95°12'44"	29°15'09"
107. Monsanto	Texas City, TX	94°53'40"	29°22'44"
108. Oxirane	Channelview, TX	95°06'29"	29°50'00"
109. Petrounited Terminal Services	Houston, TX	95°01'23"	29°33'51"
110. Phillips Petroleum	Borger, TX	101°22'05"	35°42'05"
111. Phillips Petroleum	Pasadena, TX	95°10'53"	29°43'59"
112. Phillips Petroleum	Sweeny, TX	95°45'10"	29°04'24"
113. Quintana-Howell	Corpus Christi, TX	97°27'30"	27°48'30"
114. Shell Chemical	Houston, TX	95°01'45"	29°38'15"
115. Shell Oil	Deer Park, TX	95°07'33"	29°42'55"
116. Shell Oil	Odessa, TX	102°19'20"	31°49'05"

Table C-1. PLANTS AND LOCATIONS FOR FUGITIVE EMISSION SOURCES OF BENZENE (Concluded)

Plant	Location	Coordinates Longitude	 Latitude
Region VI (concluded)			
117. Standard Oil (Indiana)	Alvin, TX	95°11'55"	29°13'06"
118. Standard Oil (Indiana)/Amoco	Texas City, TX	94°55'45"	29°21'58"
119. Sun Oil	Corpus Christi, TX	97°31'38"	27°49'57"
120. Texaco	Port Arthur, TX	93°54'43"	29°52'00"
121. Texaco/Jefferson Chemical	Port Neches, TX	93°56'00"	29°57'50
122. Union Carbide	Seadrift, TX	96°45'59"	28°30'38"
123. Union Carbide	Texas City, TX	94°56'33"	29°22'27"
124. USS Chemicals	Houston, TX	95°15'06"	29°42'18"
Region VII			
125. Chemplex	Clinton, IO	90°17'29"	41°48'24"
126. Getty Oil	El Dorado, KA	96°52'00"	37°47'10"
127. Monsanto	St. Louis, MO	90°12'00"	38°35'00"
Region IX			
128. Atlantic Richfield	Wilmington, CA	118°14'30	33°48'49"
129. Chevron	Richmond, CA	122°23'36"	37°56'12"
130. Specialty Organics	Irwindale, CA	117°55'56"	34°06'18"
131. Standard Oil of California (Chevron Chemical)	El Segundo, CA	118°24'41"	33°54'39"
132. Union Carbide	Torrance, CA	118°20'50"	33°51'11"
133. Witco Chemical	Carson, CA	118°14'13"	33°49'18"
134. Montrose Chemical	Henderson, NV	115°00'40"	36°02'28"
135. Stauffer Chemical	Henderson, NV	115°00'40"	36°02'28"

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[a] Plant no longer produces or uses maleic anhydride; therefore, it is no longer included in the analysis.

[b] Plant does not use benzene in production of maleic anhydride; therefore, it is no longer included in the analysis.

C.4 POPULATION EXPOSURE METHODOLOGY

C.4.1 Exposure Methodology

The HEM uses benzene atmospheric concentration patterns (see Section C.2) together with population information (see Section C.3) to calculate population exposure. For each receptor coordinate, the concentration of benzene and the population estimated by the HEM to be exposed to that particular concentration are identified. The HEM multiplies these two numbers to produce population exposure estimates and sums these products for each plant. A two-level scheme has been adopted in order to pair concentrations and populations prior to the computation of exposure. The two-level approach is used because the concentrations are defined on a radius-azimuth (polar) grid pattern with nonuniform spacing. At small radii, the grid cells are generally much smaller than ED/BG's; at large radii, the grid cells are much larger than ED/BG's. The area surrounding the source is divided into two regions, and each ED/BG is classified by the region in which its centroid lies. Population exposure is calculated differently for the ED/BG's located within each region.

For ED/BG centroids located between 0.1 km and 2.8 km from the emission source, populations are divided between neighboring concentration grid points. There are 96 (6 x 16) polar grid points within this range. Each grid point has a polar sector defined by two concentric arcs and two wind direction radials. Each of these grid points is assigned to the nearest ED/BG centroid identified from MED-X. The population associated with the ED/BG centroid is then divided among all concentration grid points assigned to it. The exact land area within each polar sector is considered in the apportionment.

For population centroids between 2.8 km and 20 km from the source, a concentration grid cell, the area approximating a rectangular shape bounded by four receptors, is much larger than the area of a typical ED/BG (usually 1 km in diameter). Since there is a linear relationship between the logarithm of concentration and the logarithm of distance for receptors more than 2 km from the source, the entire population of the ED/BG is assumed to be exposed to the concentration that is geometrically interpolated radially and azimuthally from the four receptors bounding the grid cell. Concentration estimates for 80 (5 x 16) grid cell receptors at 2.0, 5.0, 10.0, 15.0, and 20.0 km from the source along each of 16 wind directions are used as reference points for this interpolation.

In summary, two approaches are used to arrive at coincident concentration/population data points. For the 96 concentration points within 2.8 km of the source, the pairing occurs at the polar grid points using an apportionment of ED/BG population by land area. For the remaining portions of the grid, pairing occurs at the ED/BG centroids themselves, through the use of log-log linear interpolation. (For a more detailed discussion of the methodology used to estimate exposures, see Reference 1.)

C.4.2 Total Exposure

Total exposure (persons- $\mu g/m^3$) is the sum of the products of concentration and population, computed as illustrated by the following equation:

$$\text{Total exposure} = \sum_{i=1}^{N} (P_i C_i)$$

where

P_i = population associated with point i,

C_i = annual average benzene concentration at point i, and

N = total number of polar grid points between 0 and 2.8 km and ED/BG centroids between 2.8 and 2.0 km.

The computed total exposure is then used with the unit risk factor to estimate leukemia incidence. This methodology and the derivation of maximum lifetime risk are described in the following sections. (Note: "Exposure" as used in this appendix is the same as "dosage" in the computer printout, Docket Number IV-B-15.)

C.5 LEUKEMIA INCIDENCE AND MAXIMUM LIFETIME RISK

C.5.1 Unit Risk Factor

The unit risk factor (URF) for benzene is 9.9×10^{-8} (cases per year)/($\mu g/m^3$-person years), as calculated by EPA's Carcinogen Assessment Group (CAG). The derivation of the URF can be found in the CAG report on population risk to ambient benzene exposure[3] and updated in Response to Public Comments on EPA's Listing of Benzene Under Section 112, EPA-450/5-82-003.

C.5.2 Annual Leukemia Incidence

Annual leukemia incidence (the number of cases per year) associated with a given plant under a given regulatory alternative is the product of the total exposure around that plant (in $\mu g/m^3$-persons) and the unit risk factor, 9.9×10^{-8}. Thus,

$$\text{Leukemia cases per year} = (\text{total exposure}) \times (\text{unit risk factor}), \qquad (2)$$

where total exposure is calculated according to Equation 1 and the unit risk factor equals 9.9×10^{-8}.

C.5.3 Maximum Lifetime Risk

The populations in areas surrounding plants containing fugitive emission sources of benzene have various risk levels of leukemia incidence from exposure to benzene emissions. Using the maximum annual average concentration of benzene to which any person is exposed, it is possible to calculate the maximum lifetime risk of leukemia (lifetime probability of leukemia to any person exposed to the highest concentration of benzene) attributable to benzene emissions using the following equation:

$$\text{Maximum lifetime risk} = C_{i,max} \times (\text{URF}) \times 70 \text{ years}, \qquad (3)$$

where

$C_{i,max}$ = the maximum concentration among all plants at any receptor location where exposed persons reside,
URF = the unit risk factor, 9.9×10^{-8}, and
70 years = an individual's average life span.

C.5.4 Example Calculations

The following calculations illustrate how annual leukemia incidence and maximum lifetime risk were calculated for specific plants listed in Table C-1. Table C-2 presents the model unit number, emission rate, maximum annual average benzene concentration, and total exposure for each plant under the baseline level.

C.5.4.1 Annual Leukemia Incidence. As an example for calculating annual leukemia incidence, the Chevron plant in El Segundo, California (Number 131), is used. Under the current (baseline) level of emission

Table C-2. BASELINE DISPERSION MODELING AND EXPOSURE DATA

Plant Number	Model Unit Number[a]	Emission Rate (g/sec)	Maximum Annual Average Benzene Concentration ($\mu g/m^3$)	Total Exposure (persons-$\mu g/m^3$)
Region II				
1	10	4.50	1.69×10^{2}	2.91×10^{5}
2	10	4.50	5.00×10^{1}	1.51×10^{5}
3	60	0.72	2.71×10^{1}	6.25×10^{4}
4	9	0.93	[b]	[b]
5	2	2.70	5.00×10^{0}	4.06×10^{5}
6	9	0.93	[b]	[b]
7	30	2.02	4.80×10^{1}	1.26×10^{5}
8	21	0.73	3.24×10^{1}	1.70×10^{4}
9	2	2.70	1.20×10^{2}	3.75×10^{4}
10	45	3.45	1.11×10^{-1}[c]	4.25×10^{4}[c]
11	46	2.81	1.12×10^{-1}[c]	4.29×10^{4}[c]
12	4	0.55	1.11×10^{-1}[c]	4.25×10^{4}[c]
13	25	4.02	1.08×10^{-1}[c]	4.14×10^{4}[c]
14	24	2.10	7.17×10^{-2}[c]	1.62×10^{4}[c]
Region III				
15	23	0.99	2.35×10^{1}	6.08×10^{3}
16	2	2.70	5.00×10^{1}	9.86×10^{3}
17	4	0.55	5.37×10^{-2}	4.74×10^{2}
18	8	1.73	2.50×10^{1}	3.51×10^{3}
19	12	0.28	5.00×10^{0}	1.96×10^{3}
20	59	0.23	6.72×10^{0}	1.48×10^{4}
21	52	2.69	6.39×10^{1}	2.32×10^{5}
22	9	0.93	[b]	[b]
23	11	0.90	1.04×10^{-1}	4.60×10^{2}

Table C-2. BASELINE DISPERSION MODELING AND EXPOSURE DATA (Continued)

Plant Number	Model Unit Number[a]	Emission Rate (g/sec)	Maximum Annual Average Benzene Concentration ($\mu g/m^3$)	Total Exposure (persons-$\mu g/m^3$)
Region III (concluded)				
24	48	1.51	2.50×10^{1}	5.08×10^{4}
25	56	1.77	4.21×10^{1}	4.19×10^{4}
26	9	0.93	2.68×10^{1}	3.78×10^{4}
27	10	4.50	9.63×10^{-1}	2.35×10^{4}
28	10	4.50	1.00×10^{2}	8.00×10^{3}
29	9	0.93	d	d
30	10	4.50	4.07×10^{-1}	2.99×10^{3}
31	2	2.70	5.00×10^{1}	2.62×10^{3}
32	19	2.65	8.91×10^{1}	4.42×10^{4}
33	61	1.32	2.50×10^{1}	2.79×10^{3}
Region IV				
34	1	0.82	1.92×10^{1}	1.64×10^{4}
35	1	0.82	1.00×10^{1}	4.30×10^{3}
36	49	4.14	1.00×10^{2}	2.60×10^{4}
37	4	0.55	7.10×10^{-2}	3.62×10^{2}
38	9	0.93	1.97×10^{-1}	1.07×10^{3}
39	4	0.55	8.73×10^{-2}	6.82×10^{2}
40	21	1.10	5.87×10^{-2}	1.98×10^{3}
41	10	4.50	2.11×10^{2}	3.01×10^{4}
Region V				
42	3	0.92	2.33×10^{1}	5.73×10^{4}
43	1	0.82	1.00×10^{1}	2.56×10^{3}
44	9	0.93	c	c
45	14	7.20	1.67×10^{2}	3.15×10^{5}
46	4	0.55	5.31×10^{-2}	3.89×10^{2}
47	4	0.55	1.39×10^{1}	6.10×10^{3}
48	9	0.93	b	b

Table C-2. BASELINE DISPERSION MODELING AND EXPOSURE DATA (Continued)

Plant Number	Model Unit Number[a]	Emission Rate (g/sec)	Maximum Annual Average Benzene Concentration (μg/m³)	Total Exposure (persons-μg/m³)
Region V (concluded)				
49	21	0.73	1.69×10^{1}	9.28×10^{3}
50	23	0.99	2.50×10^{1}	1.23×10^{4}
51	26	3.10	7.83×10^{1}	3.32×10^{4}
52	13	3.62	9.14×10^{1}	2.81×10^{4}
53	56	1.77	5.83×10^{1}	6.95×10^{4}
Region VI				
54	2	2.70	2.50×10^{1}	4.97×10^{3}
55	4	0.55	1.00×10^{1}	8.06×10^{2}
56	20	0.92	1.00×10^{1}	6.28×10^{3}
57	42	2.21	1.00×10^{1}	6.33×10^{3}
58	4	0.55	1.00×10^{1}	3.13×10^{3}
59	20	0.92	1.00×10^{1}	1.49×10^{3}
60	5	1.66	5.12×10^{1}	6.00×10^{3}
61	40	2.46	5.00×10^{1}	7.05×10^{4}
62	4	0.55	1.89×10^{1}	3.13×10^{3}
63	48	1.88	1.27×10^{-1}	1.16×10^{3}
64	20	0.92	1.00×10^{1}	2.22×10^{3}
65	23	0.99	4.13×10^{1}	4.70×10^{4}
66	10	4.50	1.00×10^{2}	6.32×10^{3}
67	4	0.55	1.00×10^{1}	1.94×10^{3}
68	33	1.37	2.50×10^{1}	7.18×10^{4}
69	26	3.10	5.00×10^{1}	1.04×10^{4}
70	54	2.70	1.08×10^{2}	5.20×10^{4}
71	59	0.23	7.50×10^{0}	1.50×10^{4}
72	20	0.92	4.49×10^{1}	9.93×10^{3}
73	22	0.88	1.00×10^{1}	7.70×10^{3}
74	53	5.59	1.00×10^{2}	1.06×10^{4}

Table C-2. BASELINE DISPERSION MODELING AND EXPOSURE DATA (Continued)

Plant Number	Model Unit Number[a]	Emission Rate (g/sec)	Maximum Annual Average Benzene Concentration (μg/m³)	Total Exposure (persons-μg/m³)
Region VI (continued)				
75	39	1.92	2.50×10^{1}	1.59×10^{4}
76	27	4.21	2.06×10^{2}	5.10×10^{4}
77	47	2.98	5.00×10^{1}	1.26×10^{5}
78	6	0.64	5.00×10^{0}	3.27×10^{3}
79	59	0.23	4.48×10^{0}	2.50×10^{3}
80	43	1.63	5.31×10^{1}	9.88×10^{4}
81	44	2.43	1.03×10^{2}	3.78×10^{4}
82	57	3.10	1.32×10^{2}	1.42×10^{4}
83	4	0.55	1.00×10^{0}	3.04×10^{3}
84	56	1.77	5.00×10^{0}	5.80×10^{4}
85	9	0.93	[d]	[d]
86	20	0.92	2.18×10^{1}	3.59×10^{3}
87	58	5.24	5.00×10^{1}	2.08×10^{4}
88	4	0.55	2.50×10^{0}	3.02×10^{3}
89	10	4.50	5.00×10^{1}	2.39×10^{4}
90	4	0.55	1.00×10^{0}	3.02×10^{3}
91	4	0.55	5.00×10^{0}	2.22×10^{3}
92	18	1.47	1.00×10^{1}	1.04×10^{4}
93	17	0.83	2.41×10^{1}	7.44×10^{3}
94	32	2.21	1.00×10^{1}	2.52×10^{4}
95	59	0.23	7.50×10^{0}	9.44×10^{3}
96	3	0.92	4.49×10^{1}	1.04×10^{4}
97	7	5.14	1.00×10^{2}	5.69×10^{4}
98	5	1.66	2.50×10^{1}	4.64×10^{3}
99	36	4.50	5.00×10^{1}	2.12×10^{4}
100	2	2.70	2.50×10^{1}	3.22×10^{3}
101	23	0.99	7.50×10^{1}	4.71×10^{4}

Table C-2. BASELINE DISPERSION MODELING AND EXPOSURE DATA (Continued)

Plant Number	Model Unit Number[a]	Emission Rate (g/sec)	Maximum Annual Average Benzene Concentration ($\mu g/m^3$)	Total Exposure (persons-$\mu g/m^3$)
Region VI (concluded)				
102	23	1.53	1.22 x 10^{-1}	6.51 x 10^{2}
103	21	0.73	3.10 x 10^{1}	2.32 x 10^{4}
104	35	1.91	4.54 x 10^{1}	2.08 x 10^{4}
105	55	2.32	2.50 x 10^{1}	2.01 x 10^{4}
106	15	3.84	5.00 x 10^{1}	2.12 x 10^{3}
107	28	4.02	9.55 x 10^{1}	5.59 x 10^{4}
108	6	1.28	2.50 x 10^{1}	1.06 x 10^{4}
109	59	0.23	1.12 x 10^{1}	2.86 x 10^{3}
110	16	1.57	2.50 x 10^{1}	2.28 x 10^{3}
111	4	0.55	2.69 x 10^{1}	2.01 x 10^{4}
112	38	3.24	5.00 x 10^{1}	3.00 x 10^{3}
113	48	1.51	6.41 x 10^{1}	1.42 x 10^{4}
114	4	0.55	2.69 x 10^{1}	6.99 x 10^{3}
115	31	2.20	5.00 x 10^{1}	4.74 x 10^{4}
116	56	2.31	6.70 x 10^{1}	1.52 x 10^{4}
117	5	1.66	1.07 x 10^{-1}	2.57 x 10^{2}
118	34	3.20	7.60 x 10^{1}	2.90 x 10^{4}
119	51	4.16	1.77 x 10^{2}	2.43 x 10^{4}
120	37	2.47	2.50 x 10^{1}	2.43 x 10^{4}
121	4	0.55	1.00 x 10^{0}	5.77 x 10^{3}
122	18	1.47	5.00 x 10^{1}	6.68 x 10^{2}
123	4	0.55	1.00 x 10^{1}	5.47 x 10^{3}
124	4	0.55	1.79 x 10^{1}	2.96 x 10^{4}
Region VII				
125	4	0.55	5.00 x 10^{0}	1.25 x 10^{3}
126	35	2.45	1.00 x 10^{1}	6.81 x 10^{3}

Table C-2. BASELINE DISPERSION MODELING AND EXPOSURE DATA (Concluded)

Plant Number	Model Unit Number[a]	Emission Rate (g/sec)	Maximum Annual Average Benzene Concentration ($\mu g/m^3$)	Total Exposure (persons-$\mu g/m^3$)
Region IX				
127	9	0.93	1.00×10^1	4.14×10^4
128	41	1.54	8.07×10^1	1.35×10^5
129	23	0.99	5.20×10^1	3.71×10^4
130	2	2.70	1.41×10^2	2.07×10^5
131	35	1.91	8.71×10^1	1.36×10^5
132	4	0.55	2.51×10^1	5.11×10^4
133	8	1.73	9.07×10^1	1.72×10^5
134	2	2.70	5.00×10^1	1.36×10^4
135	1	0.82	1.00×10^1	4.13×10^3

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[a] Model unit numbers (1-56) correspond to the ones listed in Docket Number A-79-27-II-A-29, Table A-2. Model unit number 57 contains 1 sulfolane unit, 1 UDEX unit, one ethylene unit, one cyclohexane unit, and one reforming unit. Model unit number 58 contains one pyrolysis gas unit and 5 ethylene units. Model unit number 59 contains a benzene storage unit, and model units 60 and 61 contain pharmaceutical process units.

[b] Plant no longer produces or uses maleic anhydride; therefore, it is no longer included in the analysis.

[c] Since population estimate is not included in the HEM for this plant, concentration and dosage are based on estimates given at proposal. These estimates were revised to reflect an increase in emission rate for this plant.

[d] Plant does not use benzene in production of maleic anhydride; therefore, it is no longer included in the analysis.

control, the leukemia cases per year are computed according to Equation 2 as follows:

Annual leukemia incidence =1.36×10^5 (from Table C-2) $\times 9.9 \times 10^{-8}$ (cases per year)

Leukemia cases per year = 0.013

C.5.4.2 Maximum Lifetime Risk. As shown in Table C-2, Plant Number 41 (First Chemical) has the highest maximum annual average benzene concentration of 2.11×10^2 $\mu g/m^3$. Using this maximum concentration and Equation 3, maximum lifetime risk under the current (baseline) level of control is calculated as follows:

$$\text{Maximum lifetime risk} = 2.11 \times 10^2 \times 9.9 \times 10^{-8} \times 70$$

$$\text{Maximum lifetime risk} = 1.46 \times 10^{-3}$$

C.5.5 Summary of Impacts

The methodology for calculating annual leukemia incidence (described in Sections C.5.2 and C.5.4.1) was applied to each plant for three levels of emission control. Annual leukemia incidence for each plant under the three levels [baseline (current level), best available technology (BAT), and a more stringent level of control (beyond BAT)] is shown in Table C-3. The total estimated nationwide incidence of leukemia under the assumed baseline level of control is 0.45 cases per year. The estimated maximum lifetime risk, which was calculated in Section C.5.4.2 under the assumed baseline level of control, is 1.46×10^{-3}.

C.6 UNCERTAINTIES

Estimates of both leukemia incidence and maximum lifetime risk are primarily functions of estimated benzene concentrations, populations, the unit risk factor, and the exposure model. The calculations of these variables are subject to a number of uncertainties of various degrees. Some of the major uncertainties are identified below.

Table C-3. ESTIMATED ANNUAL LEUKEMIA INCIDENCE

Plant Number	Baseline	BAT	Beyond BAT
Region II			
1	2.88×10^{-2}	8.93×10^{-3}	8.06×10^{-3}
2	1.49×10^{-2}	4.62×10^{-3}	4.17×10^{-3}
3	6.19×10^{-3}	1.92×10^{-3}	1.73×10^{-3}
4	[a]	[a]	[a]
5	4.02×10^{-2}	1.25×10^{-2}	1.13×10^{-2}
6	[a]	[a]	[a]
7	1.25×10^{-2}	3.88×10^{-3}	3.50×10^{-3}
8	1.68×10^{-3}	5.21×10^{-4}	4.70×10^{-4}
9	3.71×10^{-3}	1.15×10^{-3}	1.04×10^{-3}
10	4.21×10^{-3}[b]	1.30×10^{-3}[b]	1.18×10^{-3}[b]
11	4.25×10^{-3}[b]	1.32×10^{-3}[b]	1.19×10^{-3}[b]
12	4.21×10^{-3}[b]	1.31×10^{-3}[b]	1.18×10^{-3}[b]
13	4.10×10^{-3}[b]	1.27×10^{-3}[b]	1.15×10^{-3}[b]
14	1.60×10^{-3}[b]	4.96×10^{-4}[b]	4.48×10^{-4}[b]
Region III			
15	6.02×10^{-4}	1.87×10^{-4}	1.68×10^{-4}
16	9.76×10^{-4}	3.02×10^{-4}	2.73×10^{-4}
17	4.69×10^{-5}	1.45×10^{-5}	1.31×10^{-5}
18	3.47×10^{-4}	1.08×10^{-4}	9.72×10^{-5}
19	1.94×10^{-4}	6.01×10^{-5}	5.43×10^{-5}

Table C-3. ESTIMATED ANNUAL LEUKEMIA INCIDENCE (Continued)

Plant Number	Baseline	BAT	Beyond BAT
Region III (concluded)			
20	1.46×10^{-3}	4.53×10^{-4}	4.09×10^{-4}
21	2.30×10^{-2}	7.13×10^{-3}	6.44×10^{-3}
22	a	a	a
23	4.55×10^{-5}	1.41×10^{-5}	1.27×10^{-5}
24	5.03×10^{-3}	1.56×10^{-3}	1.41×10^{-3}
25	4.15×10^{-3}	1.29×10^{-3}	1.16×10^{-3}
26	3.74×10^{-3}	1.16×10^{-3}	1.05×10^{-3}
27	2.33×10^{-3}	7.22×10^{-4}	6.52×10^{-4}
28	7.92×10^{-4}	2.46×10^{-4}	2.22×10^{-4}
29	c	c	c
30	2.96×10^{-4}	9.18×10^{-5}	8.29×10^{-5}
31	2.59×10^{-4}	8.03×10^{-5}	7.25×10^{-5}
32	4.38×10^{-3}	1.36×10^{-3}	1.23×10^{-3}
33	2.76×10^{-4}	8.56×10^{-5}	7.73×10^{-5}
Region IV			
34	1.62×10^{-3}	5.02×10^{-4}	4.54×10^{-4}
35	4.26×10^{-4}	1.32×10^{-4}	1.19×10^{-4}
36	2.57×10^{-3}	7.97×10^{-4}	7.20×10^{-4}
37	3.58×10^{-5}	1.11×10^{-5}	1.00×10^{-5}
38	1.06×10^{-4}	3.29×10^{-5}	2.97×10^{-5}
39	6.75×10^{-5}	2.09×10^{-5}	1.89×10^{-5}
40	1.96×10^{-4}	6.08×10^{-5}	5.49×10^{-5}
41	2.98×10^{-3}	9.24×10^{-4}	8.34×10^{-4}

Table C-3. ESTIMATED ANNUAL LEUKEMIA INCIDENCE (Continued)

Plant Number	Baseline	BAT	Beyond BAT
Region V			
42	5.67×10^{-3}	1.76×10^{-3}	1.59×10^{-3}
43	2.53×10^{-4}	7.84×10^{-5}	7.08×10^{-5}
44	c	c	c
45	3.12×10^{-2}	9.67×10^{-3}	8.74×10^{-3}
46	3.85×10^{-5}	1.19×10^{-5}	1.08×10^{-5}
47	6.04×10^{-4}	1.87×10^{-4}	1.69×10^{-4}
48	a	a	a
49	9.19×10^{-4}	2.85×10^{-4}	2.57×10^{-4}
50	1.22×10^{-3}	3.78×10^{-4}	3.42×10^{-4}
51	3.29×10^{-3}	1.02×10^{-3}	9.21×10^{-4}
52	2.78×10^{-3}	8.62×10^{-4}	7.78×10^{-4}
53	6.88×10^{-3}	2.13×10^{-3}	2.15×10^{-3}
Region VI			
54	4.92×10^{-4}	1.52×10^{-4}	1.38×10^{-4}
55	7.98×10^{-5}	2.47×10^{-5}	2.23×10^{-5}
56	6.22×10^{-4}	1.93×10^{-4}	1.74×10^{-4}
57	6.27×10^{-4}	1.94×10^{-4}	1.76×10^{-4}
58	3.10×10^{-4}	9.61×10^{-5}	8.68×10^{-5}
59	1.48×10^{-4}	4.59×10^{-5}	4.14×10^{-5}
60	5.94×10^{-4}	1.84×10^{-4}	1.66×10^{-4}
61	6.98×10^{-3}	2.16×10^{-3}	1.95×10^{-3}
62	3.10×10^{-4}	9.61×10^{-5}	8.68×10^{-5}

Table C-3. ESTIMATED ANNUAL LEUKEMIA INCIDENCE (Continued)

Plant Number	Baseline	BAT	Beyond BAT
Region VI (continued)			
63	1.15×10^{-4}	3.56×10^{-5}	3.22×10^{-5}
64	2.20×10^{-4}	6.82×10^{-5}	6.16×10^{-5}
65	4.65×10^{-3}	1.44×10^{-3}	1.30×10^{-3}
66	6.26×10^{-4}	1.94×10^{-4}	1.75×10^{-4}
67	1.92×10^{-4}	5.95×10^{-5}	5.38×10^{-5}
68	7.11×10^{-3}	2.20×10^{-3}	1.99×10^{-3}
69	1.03×10^{-3}	3.19×10^{-4}	2.88×10^{-4}
70	5.15×10^{-3}	1.60×10^{-3}	1.44×10^{-3}
71	1.48×10^{-3}	4.59×10^{-4}	4.14×10^{-4}
72	9.83×10^{-3}	3.05×10^{-4}	2.75×10^{-4}
73	7.62×10^{-4}	2.36×10^{-4}	2.13×10^{-4}
74	1.05×10^{-3}	3.26×10^{-4}	2.94×10^{-4}
75	1.57×10^{-3}	4.87×10^{-4}	4.40×10^{-4}
76	5.05×10^{-3}	1.56×10^{-3}	1.41×10^{-3}
77	1.25×10^{-2}	3.88×10^{-3}	3.50×10^{-3}
78	3.24×10^{-4}	1.00×10^{-4}	9.07×10^{-5}
79	2.48×10^{-4}	7.69×10^{-5}	6.94×10^{-5}
80	9.78×10^{-3}	3.03×10^{-3}	2.74×10^{-3}
81	3.74×10^{-3}	1.16×10^{-3}	1.05×10^{-3}
82	1.40×10^{-3}	4.34×10^{-4}	3.92×10^{-4}
83	3.01×10^{-4}	9.33×10^{-5}	8.43×10^{-5}
84	5.74×10^{-3}	1.78×10^{-3}	1.61×10^{-3}
85	c	c	c
86	3.55×10^{-4}	1.10×10^{-4}	9.94×10^{-5}

Table C-3. ESTIMATED ANNUAL LEUKEMIA INCIDENCE (Continued)

Plant Number	Baseline	BAT	Beyond BAT
Region VI (continued)			
87	2.06×10^{-3}	6.39×10^{-4}	5.77×10^{-4}
88	2.99×10^{-4}	9.27×10^{-5}	8.37×10^{-5}
89	2.37×10^{-3}	7.35×10^{-4}	6.64×10^{-4}
90	2.99×10^{-4}	9.27×10^{-5}	8.37×10^{-5}
91	2.20×10^{-4}	6.82×10^{-5}	6.16×10^{-5}
92	1.03×10^{-3}	3.19×10^{-4}	2.88×10^{-4}
93	7.36×10^{-4}	2.28×10^{-4}	2.06×10^{-4}
94	2.49×10^{-3}	7.72×10^{-4}	6.97×10^{-4}
95	9.34×10^{-4}	2.90×10^{-4}	2.62×10^{-4}
96	1.03×10^{-3}	3.19×10^{-4}	2.88×10^{-4}
97	5.63×10^{-3}	1.74×10^{-3}	1.58×10^{-3}
98	4.59×10^{-4}	1.42×10^{-4}	1.28×10^{-4}
99	2.10×10^{-3}	6.51×10^{-4}	5.88×10^{-4}
100	3.19×10^{-4}	9.89×10^{-5}	8.93×10^{-5}
101	4.66×10^{-3}	1.44×10^{-3}	1.30×10^{-3}
102	6.44×10^{-5}	2.00×10^{-5}	1.80×10^{-5}
103	2.30×10^{-3}	7.13×10^{-4}	6.44×10^{-4}
104	2.06×10^{-3}	6.39×10^{-4}	5.77×10^{-4}
105	1.99×10^{-3}	6.17×10^{-4}	5.57×10^{-4}
106	2.10×10^{-4}	6.51×10^{-5}	5.88×10^{-5}
107	5.53×10^{-3}	1.71×10^{-3}	1.55×10^{-3}
108	1.05×10^{-3}	3.26×10^{-4}	2.94×10^{-4}
109	2.83×10^{-4}	8.77×10^{-5}	7.92×10^{-5}

Table C-3. ESTIMATED ANNUAL LEUKEMIA INCIDENCE (Continued)

Plant Number	Baseline	BAT	Beyond BAT
Region VI (concluded)			
110	2.26×10^{-4}	7.01×10^{-5}	6.33×10^{-5}
111	1.99×10^{-3}	6.17×10^{-4}	5.57×10^{-4}
112	2.97×10^{-4}	9.21×10^{-5}	8.32×10^{-5}
113	1.40×10^{-3}	4.34×10^{-4}	3.92×10^{-4}
114	6.92×10^{-4}	2.14×10^{-4}	1.94×10^{-4}
115	4.69×10^{-3}	1.45×10^{-3}	1.31×10^{-3}
116	1.50×10^{-3}	4.65×10^{-4}	4.20×10^{-4}
117	2.54×10^{-5}	7.87×10^{-6}	7.11×10^{-6}
118	2.87×10^{-3}	8.89×10^{-4}	8.04×10^{-4}
119	2.40×10^{-3}	7.44×10^{-4}	6.72×10^{-4}
120	2.40×10^{-3}	7.44×10^{-4}	6.72×10^{-4}
121	5.71×10^{-4}	1.77×10^{-4}	1.60×10^{-4}
122	6.61×10^{-5}	2.05×10^{-5}	1.85×10^{-5}
123	5.41×10^{-4}	1.68×10^{-4}	1.51×10^{-4}
124	2.93×10^{-3}	9.08×10^{-4}	8.20×10^{-4}
Region VII			
125	1.24×10^{-4}	3.84×10^{-5}	3.47×10^{-5}
126	6.74×10^{-4}	2.09×10^{-4}	1.89×10^{-4}
127	4.10×10^{-3}	1.27×10^{-3}	1.15×10^{-3}
Region IX			
128	1.34×10^{-2}	4.15×10^{-3}	3.75×10^{-3}
129	3.67×10^{-3}	1.14×10^{-3}	1.03×10^{-3}

Table C-3. ESTIMATED ANNUAL LEUKEMIA INCIDENCE (Concluded)

Plant Number	Baseline	BAT	Beyond BAT
Region IX (concluded)			
130	2.05×10^{-2}	6.36×10^{-3}	5.74×10^{-3}
131	1.35×10^{-2}	4.18×10^{-3}	3.78×10^{-3}
132	5.06×10^{-3}	1.57×10^{-3}	1.42×10^{-3}
133	1.70×10^{-2}	5.27×10^{-3}	4.76×10^{-3}
134	1.35×10^{-3}	4.18×10^{-4}	3.78×10^{-4}
135	4.09×10^{-4}	1.27×10^{-4}	1.14×10^{-4}
TOTAL	4.50×10^{-1}	1.40×10^{-1}	1.26×10^{-1}

[a] Plant no longer produces or uses maleic anhydride; therefore, it is no longer included in the analysis.

[b] See footnote c, Table C-2.

[c] Plant does not use benzene in production of maleic anhydride; therefore, it is no longer included in the analysis.

C.6.1 Benzene Concentrations

Modeled ambient benzene concentrations depend upon (1) plant configuration, which is difficult to determine for more than a few plants; (2) emission point characteristics, which can be different from plant to plant and are difficult to obtain for more than a few plants; (3) emission rates which may vary over time and from plant to plant; and (4) meteorology, which is seldom available for a specific plant. The particular dispersion modeling used can also influence the numbers. The dispersion coefficients used in modeling are based on empirical measurements made within 10 kilometers of sources. These coefficients become less applicable at long distances from the source, and the modeling results become more uncertain. The best model to use (ISC-LT) is usually too resource intensive for modeling a large number of sources. Less complex models introduce further uncertainty through a greater number of generalizing assumptions. For example, an analysis shows that using the more complex model used to estimate ambient benzene concentrations for fugitive emission sources (equipment leaks) would increase the estimated leukemia incidences for these sources by about 100 to 200 percent (Docket Item IV-B-18). Dispersion models also assume that the terrain in the vicinity of the source is flat. For sources located in complex terrain, the maximum annual concentration could be underestimated by several fold due to this assumption. Assuming the inputs to the dispersion model are accurate, the predicted benzene concentrations are considered to be accurate to within a factor of 2.[3]

C.6.2 Exposed Populations

Several simplifying assumptions were made with respect to the assumed exposed population. The number of people was assumed to remain constant over time. In addition, those that are exposed are assumed to remain at the same location 24 hours per day, 365 days per year, for a lifetime (70 years) and are assumed to be exposed to a constant benzene concentration over time. This assumption is more likely to be valid for the children and the aged, but is not characteristic of the general population. The assumption that exposed populations remain at the same location is counterbalanced to some extent (at least in the calculation of incidence) by the assumption that no one moves into the exposure area either permanently as a resident or temporarily as a transient. The population "at risk" was assumed to reside within 20 km of each plant, regardless of the estimated concentration at that point. The selection of 20 km is considered to be a practical modeling stop-point considering the uncertainty of dispersion estimates beyond 10 km. The results of dispersion modeling are felt to be reasonably accurate within that distance (see above). The uncertainty of these assumptions has not been quantified.

C.6.3 Unit Risk Factor

The unit risk factor contains uncertainties associated with the occupational studies of Infante, Aksoy, and Ott and the variations in the dose/response relationships among the studies.[3] Other uncertainties regarding the occupational studies and the workers exposed that may affect the unit risk factor were raised during the public comment period and focus on assumptions and inconclusive data contained in the studies. However, those uncertainties have not been quantified.

C.6.4 Other Uncertainties

There are several uncertainties associated with estimating health impacts. Maximum lifetime risk and annual leukemia incidence were calculated using the unit risk factor, which is based on a no-threshold linear extrapolation of leukemia risk and applies to a presumably healthy white male cohort of workers exposed to benzene concentrations in the parts per million range. It is uncertain whether the unit risk factor can be accurately applied to the general population, which includes men, women, children, nonwhites, the aged, and the unhealthy, who are exposed to concentrations in the parts per billion range. These widely diverse population segments may have susceptibilities to leukemia that differ from those of workers in the studies. In addition, the exposed population is assumed to be immobile, remaining at the same location 24 hours per day, 365 days per year, for a lifetime (70 years). This assumption is counterbalanced to some extent (at least in the calculation of incidence) by the assumption that no one moves into the exposure area, either as a permanent resident or as a transient. Furthermore, while incidence of leukemia is the only benzene health effect considered in these calculations, it is not the only possible health effect. Other health effects, such as aplastic anemia and chromosomal aberrations, are not as easily quantifiable and are not reflected in the risk estimates. Although these other health effects have been observed at occupational levels, it is not clear whether they occur due to ambient benzene exposure levels. Additionally, benefits to the general population as the result of indirect control of other organic emissions in the process of controlling benzene emissions are not quantified. Possible benzene exposures from other sources also are not included in the estimate. For example, an individual living near a fugitive emission source of benzene is also exposed to benzene emissions from automobiles. Finally, these estimates do not include cumulative or synergistic effects of concurrent exposure to benzene and other substances.

C.7 COMPARISON OF THE HEM DISPERSION MODEL SUBPROGRAM AND ISC-LT DISPERSION MODEL

An analysis was performed using the Industrial Source Complex - Long Term Dispersion Model (ISC-LT) to evaluate the effect of using the dispersion model subprogram of the HEM.[4] The ISC-LT is considered to be a more complex and broadly applicable dispersion model than the dispersion model subprogram of the HEM, and thus serves as a good basis for comparison. In general, the main difference between the two models is that in the ISC-LT model, the benzene sources were modeled as area sources with an above-grade release height; the HEM dispersion model characterizes the sources as point sources with a ground level release height.

C.7.1 Methodology

The modeling analysis was performed in three separate steps. First, nine representative plants were chosen out of the approximately 130 existing plants that contain fugitive emission sources of benzene. Second, maximum concentrations and total exposure were calculated using the HEM with its own dispersion model subprogram. Finally, the ISC-LT was used to recalculate fugitive benzene concentrations surrounding each of the nine plants. These concentrations were then used as input into the HEM population exposure subprogram, bypassing the dispersion model subprogram. Maximum concentrations to which persons were exposed and total exposure were then calculated by the HEM using the ISC-LT concentrations as input.

C.7.2 Results

Table C-4 shows the maximum annual average concentration of benzene to which persons were exposed, as calculated by the two dispersion models, for each of the nine plants modeled. The comparison indicates that, in general, there are differences between the concentrations calculated by the HEM dispersion model subprogram and the concentrations predicted by the HEM with the ISC-LT inputs. In comparison to the ISC-LT results, the HEM maximum concentrations were smaller at six of the nine plants. Table C-5 shows the total exposure that was calculated for each of the nine plants. In all cases (i.e., nine out of nine), the results of the HEM using the HEM dispersion model subprogram predict lower total exposure than the results of the HEM using the ISC-LT input.

C.7.3 Discussion

The differences in results between the two models can be attributed partly to the differences in the handling of point versus area source dispersion of benzene fugitive emissions. The ISC-LT dispersion model places individual process units (characterized as area sources) discriminately throughout each plant. In contrast, the HEM dispersion model subprogram places all the process units at one point source, usually near the center of the plant. By modeling the process units individually, sources may be located closer to the plant boundary, and, therefore, people may be exposed to higher concentrations. The initial dispersion in the horizontal direction associated with the ISC-LT area sources could also have combined with source location to result in slightly higher exposure to the predicted benzene concentrations.

C.7.4 Conclusions

The results of the analysis indicate that total exposures for all nine plants are higher using the more sophisticated dispersion model (ISC-LT) to predict pollutant concentrations for input into the HEM than by using the HEM with its own dispersion model subprogram. Neither the ISC-LT nor the HEM dispersion model subprogram predicts higher maximum concentrations consistently due to plant-specific criteria (i.e., source locations as compared to population densities). The differences between the two model predictions are significant. However, because of the degree of uncertainty in dispersion analysis

Table C-4. COMPARISON OF MAXIMUM ANNUAL AVERAGE BENZENE CONCENTRATION OF EXPOSED PERSONS USING HEM DISPERSION MODEL AND HEM WITH ISC-LT INPUT[4]

	Maximum Concentration ($\mu g/m^3$)	
Plant Number	HEM Only	HEM with ISC-LT Input
2	5.00×10^{1}	1.00×10^{2}[a]
21	6.39×10^{1}	5.10×10^{1}
26	2.68×10^{1}	4.10×10^{1}
30	4.07×10^{-1}	7.12×10^{-1}
45	1.67×10^{2}	2.82×10^{2}
60	5.12×10^{1}	8.03×10^{1}
83	1.00×10^{0}	5.00×10^{0}
119	1.77×10^{2}	0.99×10^{2}
131	8.71×10^{1}	2.00×10^{2}[a]

[a] This plant was run with the ISC-LT in the urban mode, which tends to predict lower concentrations than the rural mode option.

Table C-5. COMPARISON OF TOTAL EXPOSURE TO BENZENE USING HEM DISPERSION AND HEM WITH ISC-LT INPUT[5]

	Total Exposure (Persons-$\mu g/m^3$)	
Plant Number	HEM Only	HEM with ISC-LT Input
2	1.51×10^{5}	3.63×10^{5}
21	2.32×10^{5}	3.00×10^{5}
26	0.38×10^{5}	1.05×10^{5}
30	2.99×10^{3}	5.78×10^{3}
45	3.15×10^{5}	7.68×10^{5}
60	0.60×10^{4}	1.89×10^{4}
83	3.04×10^{3}	8.39×10^{3}
119	2.43×10^{4}	3.68×10^{4}
131	1.36×10^{5}	1.46×10^{5}

[a] This plant was run with the ISC-LT in the urban mode, which tends to predict lower concentrations than the rural mode option.

and the degree of effort required to model all of the plants specifically, the use of a more accurate dispersion model (ISC-LT) rather than the one present in the HEM is not warranted.

C.8 REFERENCES

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3. Albert, R. E. Carcinogen Assessment Group's Final Report on Population Risk to Ambient Benzene Exposures. U.S. Environmental Protection Agency. Publication No. EPA-450/5-80-004. Docket Number II-A-28. January 1979.

4. Memorandum from Eldridge, K., Pacific Environmental Services, Inc. to Dimmick, W.F., U.S. Environmental Protection Agency. May 20, 1983. Methodology and Results of the Comparison of the HEM Dispersion Model Subprogram and the ISC-LT Dispersion Model. Docket Nubmer IV-B-18, Table 5.

5. Reference 4, Table 6.

APPENDIX D

STANDARDS-SETTING APPROACH

APPENDIX D

STANDARDS-SETTING APPROACH

D.1 INTRODUCTION

Several individuals and organizations commenting on the proposed benzene fugitive emissions standard suggested changes in the standard-setting approach used by EPA at that time. These comments and EPA's responses are discussed below.

The comments are divided into three major subjects: (1) the role of quantitative risk estimation in the regulatory process; (2) the requirement of best available technology (BAT) as the minimum level of control for significant source categories selected for regulation, and (3) the determination of the appropriate level of control for nonthreshold pollutants under Section 112.

D.2 QUANTITATIVE RISK ESTIMATION IN THE REGULATORY PROCESS

Commenters were significantly divided on the general issues of the accuracy and reliability of quantitative risk assessment (QRA) for carcinogens, as well as on the utility of such estimates in the regulatory decision making process. QRA proponents, primarily industry and trade association commenters, held that such assessments, when based on reliable data, should play an important role at all decision making stages on potential airborne carcinogens. Commenters largely from public interest groups, State air pollution control agencies, and private individuals expressed concern that the underlying uncertainties in attempts to quantify cancer risks greatly reduce the reliability of such estimates and argue for limiting or avoiding their use in the regulatory process.

EPA has considered the comments on the role of quantitative risk assessment in the regulatory decision making process for the benzene fugitive emissions standard and concludes that QRA can provide meaningful information at certain points in the decision making process. However, the importance ascribed to such information must be in proportion to its reliability. The utility of a particular estimate in the decision making process will depend on the magnitude of the estimated uncertainty. In cases for which data are inadequate to permit estimation of uncertainty, EPA will endeavor to assess qualitatively the reliability of the calculated risks and consider them accordingly in the decision making process. Where risk estimation is feasible and some measure of confidence is obtainable, EPA will perform quantitative assessments for use in the appropriate stages of the regulatory process. In the case of benzene fugitive emissions, EPA used QRA in determining that fugitive emission sources pose significant health risks to the exposed public, and in judging that the health risks after application of the level of control represented by BAT are not unreasonable in light of the cost of a more stringent control level.

D.3 SELECTION OF BAT AS THE MINIMUM LEVEL OF CONTROL

Although most commenters endorsed EPA's proposed procedure for consideration of economic and technological feasibility in the development of emissions standards under Section 112, the minimum requirement of BAT often was criticized as unnecessarily rigid and not reflective of Congressional intent. A number of commenters argued that a control level less stringent than BAT could be appropriate where the health risks are low. Several commenters argued that the imposition of BAT could result in excessive control, with no statutory support and no evidence that the avoidable risks were unreasonable.

Some commenters argued that Section 112 contained the presumption of a zero-emission standard, and contended that an evaluation of "residual risk" does not provide the mandated "ample margin of safety." The commenters stated further that EPA is not authorized to consider technical and economic factors in setting emission standards.

Several commenters suggested that health risks should be considered in establishing BAT or that cost benefit analysis should be performed. Two commenters suggested as alternatives to BAT "reasonably available control technology" and "best available retrofit technology." Finally, one commenter recommended that EPA determine acceptable risk levels in place of a BAT minimum control level.

Most carcinogens (such as benzene) seem to present finite risks at any level of exposure, risks that increase as the level of exposure increases. Standards for these pollutants could not eliminate all risk unless the standard prevents any exposure, which would in turn require preventing any emissions. It does not appear that Congress intended Section 112 standards to cause widespread shutdown of industries emitting benzene or other nonthreshold pollutants. Therefore, as an alternative to widespread shutdown of industries, EPA must establish emission standards for benzene-emitting sources that pose significant risk at levels that may still present some human health risk.

Another issue that has been encountered in using health risk estimates is whether protection should focus on the risk to the most exposed individuals or to the exposed population as a whole (cancer incidence). Even when the many uncertainties in health risk estimates are considered, results to date indicate that the total cancer incidence associated with exposure to benzene, even on a nationwide basis, is likely to be small compared to the incidence associated with factors such as smoking and diet. However, individual risks for a limited number of people living close to uncontrolled or partially controlled emission sources may be relatively high.

Neither the language nor the legislative history of Section 112 reveals any specific Congressional intent on how to deal with these issues and how to apply the phrase "provides an ample margin of safety to protect the public health" to benzene or other nonthreshold pollutants that present cancer risks at any level of exposure.

In view of this, EPA has applied the following interpretation of Section 112 to the regulation of benzene fugitive emission sources. Each source should be controlled at least to the level that reflects best available technology (BAT), and to a more stringent level if, in the judgment of the Administrator, it is necessary to prevent unreasonable health risks. In determining BAT for benzene fugitive emission sources, the Agency first identified alternative control levels that have been demonstrated. These control levels may have actually been achieved by representative plants containing fugitive emission sources of benzene or can be based on technology transfer from other source categories. The Agency determined the cost and associated impacts of the various alternatives. The Administrator selected as BAT that alternative that achieved the most emissions reduction (and therefore risk reduction) without having what he judges to be unreasonable impacts. Retrofit costs were considered since BAT was determined for existing fugitive emission sources. A particular regulatory alternative may be rejected as BAT for a variety of reasons, among them that (1) it is judged to result in a price increase that affects consumers adversely to an unreasonable extent; (2) it will result in plant closures or unreasonably discourage construction of new plants due to reduced return on investment or capital inavailability; or (3) it has unreasonably high costs for the amount of emissions reduction achieved. The level of control that represents BAT may be different for new and existing sources of benzene because of higher costs associated with retrofitting controls on existing sources, or differences in control technology for new versus existing sources. Whether the estimated health risks remaining after application of BAT are unreasonable is decided in light of a judgmental evaluation of the estimated maximum lifetime risk and cancer incidence remaining after application of BAT, the impacts, including economic impacts, of further reducing those risks, the readily available benefits of the substance or activity producing the risk, and the availability of substitutes and possible health effects resulting from their use. In all cases where estimated health risks are used, the significant uncertainties associated with those numbers were weighed carefully in reaching the final decision.

In EPA's judgment, benzene fugitive emission standards based on this interpretation of Section 112 provide an ample margin of safety to protect the public health.

In summary, BAT represents a level of technology that reduces emissions to the greatest extent possible, given cost, energy, environmental, and technological factors. As such, it is a reasonable level of control that may, based on an evaluation of the health risks remaining after its application and the costs of further reducing those risks, provide an "ample margin of safety" to protect public health. In view of the carcinogenic nature of benzene, which is regulated under Section 112, application of BAT to fugitive emission sources of benzene posing signficant health risks, therefore, imposes the least stringent control level possible that is judged to protect public health with an ample margin of safety (assuming, of course, that the residual risk remaining after application of BAT is not unreasonable).

In response to the commenter who recommended that EPA determine acceptable risk levels in setting standards rather than require BAT as a minimum, EPA continues to believe that the adoption of acceptable specific risk levels or cost per life is inappropriate. Even for the residual risk analysis, because of the shortcomings of quantitative risk assessments, and the inability of cost-per-life calculations to deal with unacceptably high risks to smaller groups, EPA does not believe that cost-per-life calculations are appropriate as the principal means of assessing residual risks.